SNU 84-1
Revision D

SPECIFICATION

FOR

USAF STANDARD

FORM, FIT, AND FUNCTION (F^3)

MEDIUM ACCURACY

INERTIAL NAVIGATION UNIT

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AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AFB, OH

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This specification establishes the requirements in terms of Form, Fit, and Function (including performance) for an Inertial Navigation Unit (INU) applicable to a broad spectrum of vehicles. It is the intent of this specification to define the INU requirements such that multiple contractor designed and produced hardware can be used interchangeably at the Line Replaceable Unit (LRU) level in any given vehicle. The unique CDU interface is no longer part of this specification, and is now covered in SNU 84.1/F-16.

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1. SCOPE

This specification establishes the requirements in terms of Form, Fit, and Function (including performance) for an Inertial Navigation Unit (INU) applicable to a broad spectrum of vehicles. It is the intent of this specification to define the INU requirements such that multiple contractor designed and produced hardware can be used interchangeably at the Line Replaceable Unit (LRU) level in any given vehicle. The unique CDU interface is no longer part of this specification, and is now covered in SNU 84-1/F-16.

2. APPLICABLE DOCUMENTS

2.1 Government Documents

The following documents shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered as superseding requirements.

SPECIFICATIONS AND STANDARDS

Federal

FED-STD-595A 1 Feb 1980	Color
OSHA Standard 1910-93 18 Oct 1972	Code for Federal Regulations

Military

MIL-B-5087B (2) 31 Aug 1970	Bonding, Electrical, and Lightning Protection, For Aero-space Systems
MIL-E-5400T (1) 5 Sept 1980	Electronic Equipment, Aerospace, General Specification For
MIL-H-5606E 29 Aug 1980	Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance
MIL-T-5624L 16 Jun 1980	Turbine Fuel, Aviation, Grade JP-4 and JP-5
MIL-E-6051D (1) 5 Jul 1968	Electromagnetic Compatibility Requirements, Systems
MIL-M-7793D 31 Dec 1969	Meter, Time Totalizing
MIL-L-7808H 1 Nov 1977	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-A-8243C 17 Nov 1980	Anti-icing and Deicing - Defrosting Fluid

MIL-T-83133A (1) 4 Apr 1980	Turbine Fuel, Aviation, Kerosene Type, Grade JP-3
MIL-H-83282A 22 Feb 1974	Hydraulic Fluid, Fire Resistant Synthetic Hydrocarbon Base, Aircraft
MIL-C-83733B 10 Dec 1980	Connector, Electrical, Miniature, Rectangular Type, Rack to Panel, Environmental Resisting, 200 Degrees C Total Continuous Operating Temperature, General Specification For
MIL-HDBK-217D 15 Jan 1982 Notice 1 13 Jun 1983	Reliability Prediction of Electronic Equipment
MIL-STD-108E 4 Aug 1966	Definition of and Basic Requirement for Enclosure for Electric and Electronic Equipment
MIL-STD-130E 5 Aug 1977	Identification Marking of U.S. Military Property
MIL-STD-415D/ Notice 1 1 Oct 1969/ 8 Oct 1971	Test Provisions for Electronic Systems & Associated Equipment, Design Criteria For
MIL-STD-454G/ Notice 3 1 Mar 1976/ 10 Sept 1981	Standard General Requirements for Electronic Equipment
MIL-STD-461A/ Notice 3 1 Aug 1968/ 1 May 1970	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462/ Notice 2 31 Jul 1967/ 1 May 1970	Electromagnetic Interference Characteristics, Measurements of
MIL-STD-471A/ Notice 2 27 Mar 1973/ 8 Dec 1978	Maintainability Demonstration
MIL-STD-704A/ Notice 3 9 Aug 1966/ 11 Apr 1973	Electric Power, Aircraft Characteristics and Utilization of
MIL-STD-781C/ Notice 1 21 Oct 1977/ 20 Mar 1981	Reliability Tests Exponential Distribution

MIL-STD-810C/ Notice 1 10 Mar 1975/ 07 Apr 1981	Environmental Test Methods and Engineering Guidelines
MIL-STD-882A 28 Jun 1977	System Safety Program Requirements
MIL-STD-883A(1) 15 Nov 1974	Test Methods and Procedures for Microelectronics
MIL-STD-1472C 2 May 1981	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD-1553B/ Notice 1 21 Sep 1978/ 12 Feb 1980	Aircraft Internal Time Division Command/ Response Multiplex Data Bus
MIL-STD-1589C 6 Jul 1984	JOVIAL (J73)
MIL-STD-1750A 2 Jul 1980 Notice 1 21 May 1982	Sixteen Bit Computer Instruction Set Architecture
DOD-STD-1686 2 May 1980	Electrostatic Discharge Control Program for Protection of Electrical and Electronics Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) (Metric)
MS17322E 31 Dec 1969	Meter, Time Totalizing, Miniature Digital 115V, 400Hz
MS25083K 8 May 1980	Jumper Assembly, Electric Bonding and Current Return
MS25271E 3 Nov 1975	Relay, 10 Amp, 4 PDT, Type I, Hermetically Sealed, Solder Hook
MS27505E Mounting 11 Jul 1980	Connector, Receptacle, Electrical, Back Panel, Box Box Flange, Crimp Type, Bayonet Coupling, Series 1
MS33660A Oct 1959	Tubing End, Hose Connection, Standard Dimensions For 28 (ASG)

AFM 39-1 29 Dec 1969	Airman Classification Manual
AFSC DH 1-4	Design Handbook for Electromagnetic Compatibility
AFSC DH 1-6	Design Handbook for System Safety

Other Publications

FAR 121-89, Appendix G 29 Apr 1972	Doppler Radar and Inertial Navigation Systems
ASCC AIR STD 53/11D 30 Apr 1990	The Specification for Evaluation of the Accuracy of Navigation System
DMA TM 8358.1 30 June 1986	Datums, Ellipsoids, Grids, and Grid Reference Systems
WC90	National Geophysical Data Center World Chart (WC) WC90 Model
GEOMAG	NGDC Fortran Program

2.2 Non-Government Documents

The following documents shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered as superseding requirements.

NONE

3. REQUIREMENTS

3.1 Item Description

This Inertial Navigation Unit (INU) shall be a self-contained, all-attitude navigation set providing outputs of linear and angular acceleration, velocity, position, heading, attitude (roll, pitch and azimuth), baro-inertial altitude, body angular rates and time tags. The INU shall require vehicle electrical power, turn-on and mode commands, initialization data, and pressure altitude data for unaided inertial operation. In addition, the INU shall be capable of interfacing with an external computer, via serial digital multiplex lines, which can request data and transmit update data based on their avionics sensors (e.g., LANTIRN, Doppler radar, position fixes, GPS, etc.). The aircraft inertial navigation system shall be comprised of three (3) Line Replaceable Units (LRUs):

a. Inertial Navigation Unit (INU)
b. Control Display Unit (CDU) (Reference only)
c. INU Mount (Reference only)

3.1.1 Item Diagram

Deleted.

3.1.2 Interface Definition

The signal interface between the INU and vehicle avionics shall conform to the input/output signals listed in Appendices I, II, III and VI. The parameters which the INU shall provide to and receive from other vehicle avionics shall be grouped into message sets as referenced in the appendices and shall be available 5 seconds maximum subsequent to receipt of the INU Turn-On discrete. Mode transitions shall be delayed for 8 seconds maximum, after the turn-on discrete is received. This period is to allow the INU to perform its power up routines, health checks, initialization, and transitions to the STBY mode. Serial digital data transfer between the INU and other avionics subsystems shall be accomplished in accordance with Appendix VI. Interfacing systems shall monitor INU status reported in MUX messages and/or discretes for moding decisions.

3.1.2.1 Bus Control

In accordance with Appendix VI, paragraph 60.4.4.

3.1.2.1.1 Data Bus Redundancy

In accordance with Appendix VI, paragraph 60.4.4.2.2.

3.1.2.1.2 Bus Address

In accordance with Appendix VI, paragraph 60.4.2.2.2.2.

3.1.2.1.3 Status Word Bit Assignment

In accordance with Appendix VI, paragraph 60.4.2.2.3.

Figure 1 - Deleted

3.1.2.1.4 Mode Commands

In accordance with Appendix VI, paragraph 60.4.2.2.2.7.

3.1.2.1.5 Input/Output (I/O)

The I/O shall contain registers and the associated logic necessary to receive and transmit serial binary coded decimal (BCD) and binary (BNR) data. Analog I/O shall be comprised of solid-state devices and external excitation shall be used for all digital-to-analog signals. 28 VDC discrete signal power shall be furnished by the vehicle DC bus through pins 5 and 6 of connector J-132.

3.2 Characteristics

3.2.1 Performance

These performance requirements apply for all flight and ground environments called out in paragraph 3.2.5 and subparagraphs thereof. The INU shall be capable of determining position, velocity, heading, accelerations, body rates, and attitude to the accuracies specified herein in an autonomous mode from take-off to landing after a ground alignment in any of the following modes:

a. Gyrocompass (GC)
b. Stored Heading (SH)
c. Best Available True Heading (BATH)

3.2.1.1 Position Accuracy

The INU shall provide present position determination with a Radial Error Rate (RER) of 0.8 nmi/hr (1.48 km/hr) Circular Error Probable (CEP) or less for flight times up to one hour after a complete gyrocompass or stored heading alignment. For flight times greater than one hour (with a gyrocompass alignment), the INU shall meet the performance requirements set forth for the civil environment (FAR 121-89, Appendix G) which states that the Inertial Navigation Unit must meet the following accuracy requirements, as appropriate:

a. For flights up to 10 hours duration, no greater than 2.0 nmi/hr (3.7 km/hr) of circular error on 95 percent of systems flights completed is permitted.

b. For flights over 10 hours duration, a tolerance of ±20 nmi (37 km) cross-track and ±25 nmi (46 km) along-track on 95 percent of systems flights completed is permitted.

3.2.1.2 Velocity Accuracy

In accordance with Table I.

3.2.1.3 Acceleration Accuracy

In accordance with Table I.

3.2.1.4 Attitude Accuracy

In accordance with Table I.

3.2.1.5 Altitude Accuracy

The steady state baro-inertial altitude error shall not exceed 150 feet, whenever valid pressure altitude is being received by the INU. Errors in pressure altitude input to the INU will affect the accuracy of the INU outputs.

3.2.1.5.1 Performance of the Vertical Channel

The INU shall accept full scale/step inputs without overflowing registers. Peak vertical velocity error during the dive flight profile shall not exceed 2.0 fps, and vertical velocity and acceleration outputs shall comply with the accuracy and jitter requirements specified in Table I of this specification.

a. Pressure Altitude Input. The pressure altitude input may have transient errors as large as 500 feet with 0.3 seconds lag during steep dives. Errors of 2,000 feet in pressure altitude from level flight prior to the dive to level flight after the dive may occur. Full scale/step inputs during level flight may occur.

b. Dive Flight Profile. The dive flight profile shall be defined as follows:

Pull-Down into Dive	4 g
Dive Angle	60 degrees
Sink Rate	750 fps
Pull-Up to Level	4 g
Duration (level flight to level flight)	60 seconds

3.2.1.6 Reaction Times

Reaction time requirements are as shown in Table I. All times include initialization.

3.2.1.7 Latitude Range

The INU shall operate at all latitudes. The gyrocompass alignments in Table I are restricted to latitudes between 78 degrees North and 78 degrees South. The accuracies given in Table I shall apply between 55 degrees North latitude and 55 degrees South latitude. Performance for alignments above 55 degrees North latitude and below 55 degrees South latitude shall be in accordance with the following equations:

$$HLCEP = CEP_{o} * [0.574 + 0.245 * \text{secant}(AL)]$$

$$HLTH = TH_{o} * [0.574 * \text{secant}(AL)]$$

Where AL = Alignment Latitude

CEP_{o} = Position Rate Error from Table I

TH_{o} = True Heading Error from Table I

HLCEP (High Latitude CEP) is defined to be the worst case CEP performance for alignments above 55 degrees North latitude and below 55 degrees South latitude. HLTH (High Latitude True Heading) is defined as the worst case RMS true heading error corresponding to the same conditions as HLCEP. The HLCEP and HLTH multiplication factors in the above equations are applicable to the True Heading, Mag Heading, and CEP in Table I for the Full GC, Degraded GC, EIA, and SH requirements.

The following table gives examples of calculated values of HLCEP and HLTH performance for an eight (8) minute alignment.

North/South Latitude degrees	HLCEP nmi/hr	HLTH degrees
55	0.80	0.100
60	0.85	0.115
65	0.92	0.136
70	1.03	0.168
75	1.22	0.222
78	1.40	0.276
above 78	** not specified **	

3.2.1.8 Vehicle Motion During Gyrocompass Alignment

The INU shall meet the requirements of this specification for gyrocompass alignments when subjected to normal wind buffeting and normal ground maintenance activities. Air vehicle motion during alignment will be characterized by 0.05g at 1.0 Hz lateral displacement, plus a 2 cm movement in 0.5 seconds at the least opportune moment during alignment.

Table I - Performance Requirements

	FULL GC	DEGRADED GC	EIA	SH	BATH	ATT
MAXIMUM ALIGN TIME (minutes)	8.0	1.5	8.0 **	1.5	1.5	-
(-40 to +71 Degrees Celsius)	-	-	TAXI	-	-	-
	-	-	4.0 **	-	-	-
POSITION ACCURACY (nmi/hr)						
Flights ≤ 1.0 hr (CEP)	0.8	5.0	0.5	0.8		
Flights >1 and ≤ 10.0 hr (95% of all flights)	2.0	-	2.0	-	-	-
Flights > 10.0 hr (95% of all flights)						
CROSS TRACK (nmi)	±20	-	±20	-	-	-
ALONG TRACK (nmi)	±25	-	±25	-	-	-
VELOCITY ACCURACY						
Linear (X,Y) $\tau \leq 1$ min (fps)	2.5 RMS*	-	0.15 ***	5.0RMS*	-	-
$1 < \tau \leq 2$ min (fps)	2.5 RMS*	-	0.3 ***	-	-	-
$2 < \tau \leq 5$ min (fps)	2.5 RMS*	-	0.4 ***	-	-	-
$\tau \geq 5$ min (fps)	2.5 RMS*	-	2.0 RMS*	-	-	-
Linear (Z) (fps RMS)	2.0 *	-	2.0 *	3.0 *	-	-
Linear (N,E) (fps RMS)	2.5 *	-	2.5 *	-	-	-
Angular (P,Q,R) (deg/sec RMS)	0.043 *	-	0.043 *	-	-	-
ACCELERATION ACCURACY						
Linear (X,Y,Z) (ft/s/s RMS)	0.064 *	-	0.064 *	-	-	-
Linear (Lateral, Longitudinal,		-		-	-	-
Normal) (ft/s/s RMS)	2.0 *	-	2.0 *	-	-	-
Angular (deg/s/s)	10.0	-	10.0	-	-	-
STATIC ATTITUDE (ROLL, PITCH, PLATFORM AZ)						
Digital (deg RMS)	3 min RMS 0.05	0.1	0.05	0.1	0.1	-
Analog (deg RMS)	4.02 min RMS 0.067	0.1	0.067	0.1	0.1	-
True Heading (deg)	0.1 RMS	0.5 RMS	0.1 RMS	0.1 RMS	-	15/hr
Magnetic Heading (deg)	0.3 RMS	1.0 RMS	0.3 RMS	0.3 RMS	-	15/hr

* For flights up to two hours.

** 8 Minute GC Align, Taxi to new heading ≥ 70 degrees delta, (taxi time ≤ 10 minutes), 4 Minute GC Align.

*** One Sigma Value.

τ A period starting at the selection of the NAV mode.

Table I - Performance Requirements (continued)
STANDARD INU JITTER AND DELAY REQUIREMENTS

F^3 OUTPUT PARAMETER	UNITS	REFRESH RATE(HZ)	LSB VALUE	ACCURACY** (RMS)	JITTER* ** (RMS)	RESPONSE TIME*	BANDWIDTH (HZ)*	OUTPUT MESSAGES
True Heading	Pirads	200 50 50	3.05176E-5	5.57042E-4 (0.1 deg)	6.66667E-5 (0.012 deg)	10 ms@200 Hz 20 ms@ 50 Hz	25	IH1-03 I01-12 I06-12
Roll	Pirads	200 200 50 50	3.05176E-5	2.76930E-4 (0.05 deg)	6.66667E-5 (0.012 deg)	10 ms@200 Hz 20 ms@ 50 Hz	25	I09-10 IH1-02 I01-10 I06-10
Pitch	Pirads	200 200 50 50	3.05176E-5	2.76930E-4 (0.05 deg)	6.66667E-5 (0.012 deg)	10 ms@200 Hz 20 ms@ 50 Hz	25	I09-11 IH1-01 I01-11 I06-11
Velocity North	fps	200	0.125	2.5	0.25	20 ms	5	IH1-04
Velocity East	fps	200	0.125	2.5	0.25	20 ms	5	IH1-05
Vert. Velocity	fps	200	0.0625	2.0	0.25	20 ms	5	IH1-06
X Velocity	fps	200 200 50 50	3.81470E-6	2.5	0.002	20 ms@200 Hz 26 ms@ 50 Hz	21	I09-03,04 IH1-08,09 I01-03,04 I06-03,04
Y Velocity	fps	200 200 50 50	3.81470E-6	2.5	0.002	20 ms@200 Hz 26 ms@ 50 Hz	21	I09-05,06 IH1-10,11 I01-05,06 I06-05,06
Z Velocity	fps	200 200 50 50	3.81470E-6	2.0	0.002	20 ms@200 Hz 26 ms@ 50 Hz	21	I09-07,08 IH1-12,13 I01-07,08 I06-07,08
Pitch Rate	Pirads/ Sec	200 50	1.22070E-4	2.38732E-4 (0.043 deg/s)	2.00000E-4 (0.036 deg/s)	20 ms@200 Hz 25 ms@ 50 Hz	21	I09-13 I01-31
Roll Rate	Pirads/ Sec	200 50	1.22070E-4	2.38732E-4 (0.043 deg/s)	2.00000E-4 (0.036 deg/s)	20 ms@200 Hz 25 ms@ 50 Hz	21	I09-12 I01-30
Yaw Rate	Pirads/ Sec	200 50	1.22070E-4	2.38732E-4 (0.043 deg/s)	2.00000E-4 (0.036 deg/s)	20 ms@200 Hz 25 ms@ 50 Hz	21	I09-14 I01-32

Table I - Performance Requirements (continued)
STANDARD INU JITTER AND DELAY REQUIREMENTS

F^3 OUTPUT PARAMETER	UNITS	REFRESH RATE(HZ)	LSB VALUE	AC[illegible] ** (R[illegible]	JITTER* ** (RMS)	RESPONSE TIME*	BANDWIDTH (HZ)*	OUTPUT MESSAGES
Lat. Accel	fps^2	200	0.03125	2.0	0.49	20 ms	21	I09-16
Long. Accel	fps^2	200	0.03125	2.0	0.49	20 ms	21	I09-15
Normal Accel	fps^2	200	0.03125	2.0	0.49	20 ms	21	I09-17
Plat. Azimuth	Pirads	200 200 50 50	3.05176E-5	2.76930E-4 (0.05 deg)	6.66667E-5 (0.012 deg)	10 ms@200 Hz 20 ms@ 50 Hz	25	I09-09 IH1-07 I01-09 I06-09
Mag. Heading	Pirads	50 50	3.05176E-5	1.11090E-3 (0.2 deg)	9.8671E-5 (0.018 deg)	20 ms	25	I01-13 I06-13
Pitch Accel	Pirads/ sec^2	200	2.44141E-4	5.41127E-2 (10 deg/sec^2)	7.22222E-3 (2.0 deg/sec^2)	23 ms	17	I09-22
[illegible]ll Accel	P[illegible]:/ s[illegible]	20C	2.44141E-4	5.41127E-2 (10 deg/sec^2)	7[illegible].222E-3 ([illegible] deg/sec^2)	23 ms	17	I09-21
[illegible] Accel	P[illegible] s[illegible]	20C	2.441[illegible]1E-4	5.41127E-2 (10 deg/sec^2)	[illegible]:22E-3 [illegible] deg/sec^2)	23 ms	17	I09-23
Iner. Altitude	f[illegible]	5C	4.0	150.0	[illegible]	20 ms	-	I01-25
Accel X	fps[illegible]	50	0.03125	0.064	[illegible].49	30 ms	16	I01-14
Accel Y	fps^2	50	0.03125	0.064	0.49	30 ms	16	I01-15
Accel Z	fps^2	50	0.03125	0.064	0.49	30 ms	16	I01-16

* Jitter, Data Response Time, and Bandwidth are defined in paragraphs 6.7.1 through 6.7.5.
** Accuracy and Jitter values are for a Full Performance GC Alignment.
NOTE: Specification requirements for evaluating the CIGTF "S" turn test (see Table VII) shall be the three (3) sigma values of limits specified in this table.

3.2.1.9 INU Functions

The INU shall provide the following functions:

a. Present position and Waypoint/Markpoint Insertion. Provide for manually inserting local geodetic latitude and longitude (L/L), and alpha-numeric Universal Transverse Mercator (UTM) coordinates via the MUX Bus. Entry of destination coordinates into the INU shall be implemented as follows:

   (1) Destination zero shall automatically be loaded with the present position when present position is entered during alignment whether using L/L or UTM coordinates.

   (2) Entry of L/L into a selected destination (Present Position or Waypoint/Markpoint) in the INU shall set a memory bit internal to the INU recording that destination as a L/L entered destination. The same spheroid as that entered during the last UTM entry for that destination shall be used. Once a destination has been recorded as a L/L entered destination, the entry of UTM coordinates into that location will cause the following to occur:

      (a) If a UTM entry is made where only the spheroid number is different from that transmitted by the INU for that destination, the INU shall interpret this UTM entry as a change of spheroid only. Whereupon the UTM coordinates will be updated to reflect that same location on the earth in the spheroid just entered with the destination still recorded in the INU as being L/L entered.

      (b) If, however, a UTM entry is made where either the grid zone, 100,000 meter area, eastings or northings change from that transmitted by the INU for that destination, the INU shall accept this UTM entry as a new entry and flag it internally as a UTM entered destination.

      (c) Reference on this subject is DMA TM 8358.1 (Datums, Ellipsoids, Grids, Grid Reference Systems).

      (d) UTM/Geodetic Position Conversion. When INU latitude and longitude is converted to UTM coordinates, the accuracy of the conversion shall be within 50 meters for standard U.S. Military Grid References. The conversion for all other Grid References shall be within 100 meters. Repeated conversions from geodetic to UTM to geodetic position may result in position ambiguities; but initial conversion from geodetic position to UTM coordinates shall be in accordance with the above requirements.

   (3) Entry of a new UTM location into a destination in the INU which has been previously recorded as a UTM entered destination shall be accepted and implemented in total even if the difference between the old and newly entered UTM destination is only a change in the spheroid number. A corresponding change will occur in the L/L output from the INU.

3.2.1.9a (continued)

(4) Markpoints are normally entered either by operator manual entry, by depressing the MARK button on the CDU, or by depressing the designate switch. Using one of the last two methods listed, the value of present position (PPOS) is automatically inserted into the next available markpoint location. If the next markpoint location is the selected steerpoint, it is not available. In this case, the value of PPOS is inserted into the markpoint location following the selected steerpoint. Examples of markpoint entries:

(a) Last markpoint A; current steerpoint C; pilot depresses MARK; PPOS is inserted into markpoint B.

(b) Last markpoint B; current steerpoint C; pilot depresses MARK; PPOS is inserted into markpoint D since C is the steerpoint.

b. Align Status. Provide an align progress indication. Align status codes shall be used for operator information only and shall not imply system performance requirments (see I07-19).

c. Calibration. Calibration shall be required no more frequently than 60 days for systems which have a selectable "CAL" mode mechanized (see paragraph 3.2.1.10h). Systems not mechanizing the selectable "CAL" mode shall require calibration no more frequently than 18 months.

d. Automatic Magnetic Variation Computation. The INU shall automatically compute magnetic variation (MV) in all regions of the earth. The computations will be based on the NGDC Geological Survey using the NGDC Fortran Program GEOMAG to generate coefficients based on the WC-90 model extrapolated to 1995.0, altitude 10,000 feet (3.048 km). Above 72 North latitude or below 60 South latitude, computed MV shall be based on longitude and 72 degrees North or 60 degrees South latitude. MV from this computation shall be added in the INU to true heading in the computation of all magnetic heading outputs; however, if MV has been manually entered, it shall be used in lieu of computed MV. The ability to select or deselect any manually entered MV shall be controlled by D01-02, bit 12. The accuracy of the MV computation shall be ±0.2 degrees assuming that reference data supplied by the government is errorless.

e. Self-Test. Provide for inflight and on-the-ground self-test to monitor INU operation and provide an appropriate indication when the INU is not operating properly in addition to transmitting a degraded mode signal(s) to other equipment. Fault codes for the INU malfunctions shall be stored in the non-volatile memory.

3.2.1.9 (continued)

f. Attitude. Determine and maintain a continuous knowledge of the vehicle attitude relative to local geodetic vertical, transmit roll, pitch and platform azimuth (X axis displacement from INU boresight axes) to other equipment, and serve as a back up attitude reference in the "ATT" mode.

g. True Heading. Determine and maintain a continuous knowledge of the vehicle longitudinal axis azimuth relative to true north, and transmit true heading to other equipment or accept true heading as manually inserted during a BATH alignment.

h. Acceleration. Determine and maintain a continuous knowledge of the vehicle acceleration and transmit the three orthogonal accelerations in the INU navigation reference frame (X, Y, and Z) and body accelerations.

i. Velocity. Determine and maintain a continuous knowledge of the vehicle velocities relative to the ground and transmit the three orthogonal velocities in the INU navigation reference frame (X, Y, and Z) and angular rates (p, q, and r) to other equipment.

j. Present Position. Continuously compute and make available for display, vehicle present position altitude and geographic latitude/longitude coordinates. Latitude/longitude coordinates shall also be made available in alpha-numeric UTM coordinates for transmission to other equipment.

k. Position Update. Correct present position while airborne by

   (1) overflying a known position which has been inserted via the data bus, or

   (2) accepting present position signals via a correction vector.

When either the "AUXILIARY" or "OVERFLY" update mode described in paragraph 3.2.1.10g herein is selected, the difference between INU computed present position and the actual known position (however inserted) shall be computed as N/S and E/W errors in nautical miles and tenths and transmitted via the data bus for display. When the "AIR ALIGN" update mode described in paragraph 3.2.1.10g herein is selected, the present "pure inertial" position is updated with the input sensor present position signals contained in the correction vector.

3.2.1.9 (continued)

l. Steering. Compute and make available as outputs course, course deviation, range to destination, time to destination, ground track and steering error for steering to any of 10 destinations and six Markpoint locations. Markpoints may be transmitted to the INU via the MUX bus or established internal to the INU in response to a CDU MARK command or a designate Discrete MARK command when an Overfly Fix (Function Select Code 00101) is not being commanded.

m. Back Up Bus Control. Serve as a back up controller on Network I only.

n. Back Up Attitude. Serve as a back up attitude reference.

o. Auto-mode Transition. Detection of motion that will cause INU alignment degradation beyond the INU's ability to provide performance in accordance with Table I shall result in INU automatically transitioning to NAVIGATE mode if "Degraded NAV Ready" has been achieved. This shall be referred to as "Auto-Mode." If motion is detected prior to "Degraded NAV Ready," the INU shall transition to the Attitude mode. Once an Auto-Mode transition has occurred, the INU shall provide the applicable indications, e.g. INU I01-01, I01-29, I06-01 mode words, to other subsystems that the INU is in the NAV or ATT mode. This event shall be recorded in the INU Align Events history. Activation of this mode shall not inhibit RER calculations provided a contiguous full performance alignment has been completed. This event shall not prevent the performance of EIA provided that the normal alignment criteria of paragraph 3.2.1.10c(2) have been otherwise satisfied. The application of Auto-Mode is further described in para 3.2.1.10c(2).

p. Mode Status. A mode status indication in the form of a mode word shall be provided to the interfacing weapon system via the serial digital lines indicating an INU controlled mode status, including indication of when a position and velocity update is applied.

q. Non-Volatile Memory Storage. The INU shall provide sufficient non-volatile memory storage capability to retain a history of destination/markpoint coordinates, initialization coordinates and heading, specified alignment and navigation events, results of self tests, and record of navigation performance on previous flights to include, as a minimum, INU standard MISC PARAMETER INSERT/READ functions coded 0 to 100 inclusive.

3.2.1.9q (continued)

(1) Record of ALIGN Events. INU standard MISC PARAMETER 62 shall be used to provide the record of ALIGN Events. The MISC PARAMETER READ output address where this record is stored shall be cleared and the current Align Events record shall be stored at each ALIGN-TO-NAV or ALIGN-TO-ATTITUDE transition. The following binary coded ALIGN events shall be provided as one of the standard MISC PARAMETER READ outputs:

000000	GC Align
000001	BATH Align
000010	Stored Heading Align
000100	Auto-Mode Transition
001000	Early selection of NAV (Degraded NAV)
010000	Align Re-Entry (For any reason)
100000	Present position not entered (Degraded NAV)

(2) Record of time in the ALIGN mode. INU standard MISC PARAMETER 63 shall be used to provide time in ALIGN mode. The time shall be updated at each ALIGN-TO-NAV or ALIGN-TO ATTITUDE transition and shall be formatted as "XXXX.X" minutes.

(3) Record of NAV Events. INU standard MISC PARAMETER 64 shall be used to provide the record of NAV Events. NAV events shall be stored as they occur and cleared at each ALIGN-TO-NAV or ALIGN-TO-ATTITUDE transition. The following binary coded NAV events shall be provided as one of the standard MISC PARAMETER READ outputs:

000000	No NAV Events
000001	Overfly Update accepted
000010	Auxiliary Update accepted
000100	Air Align Update accepted
001000	Cumulative CEP Update accepted
010000	Navigation-Alignment Refining Feature (NARF)

(4) Record of time in the NAV mode (includes the "Overfly" and "Air Align" Update modes). INU standard MISC PARAMETER 65 shall be used to provide the record of time in the NAV mode. The time in MISC PARAMETER 65 shall increment when the NAV mode is entered either by an Auto-Mode transition or an FSC selection. During the current operating cycle (power cycle), the first ALIGN to NAV transition shall reset MISC PARAMETR 65. If the INU reenters the ALIGN mode after being switched to the NAV mode, MISC PARAMETER 65 shall not increment. If NARF is implemented, MISC PARAMETER 65 shall not increment while this function is active. A Ground Speed of ≥ 80 knots shall disable this feature for the remainder of this operating (power) cycle. MISC PARAMETER 65 shall be displayed as "XXXX.X" minutes.

3.2.1.9q (continued)

(5) Mission Radial Error Rate (RER). INU standard MISC PARAMETER READ Code 19 shall be used to provide the mission RER. This RER shall be automatically computed by the INU and output for display upon receipt of a MISC PARAMETER READ Code 19.

(a) Mission RER shall be formatted as "RERX.X" except that "RER NA" shall be output whenever any of the following conditions exist:

(1) A BATH, SH, or Degraded Performance Alignment was performed.

(2) An "Air Align" update has been accepted by the INU.

(3) Present groundspeed exceeds 80 knots.

(4) The INU is in the Attitude mode.

(b) Mission RER shall be output as "RER9.9" whenever the actual value equals or exceeds 9.9 nmi/hr.

(c) The mission RER shall be computed by dividing displacement distance by the elapsed time in the NAV mode. Displacement distance shall be computed by converting the distance between the selected Destination Waypoint/Markpoint (DEST WP/MP) latitude/longitude and the "pure inertial" latitude/longitude to radial distance in nautical miles. Note that manual or semi-automatic updates shall not inhibit computation of mission RER, since "pure inertial" values are used.

(d) When terminating a mission, the operator must identify the terminal base location to the INU in order that the INU may compute a valid mission RER. This is accomplished by insuring that the selected DEST WP/MP at the time MISC 19 is entered contains the coordinates of the terminal base. However, selection of a different DEST WP/MP or entry of new latitude or longitude coordinates into the selected DEST WP/MP shall cause a new mission RER to be computed and output. The "pure inertial" and terminal base position data used for computing the mission RER shall be stored in MISC registers as follows:

(1) MISC 22 - Terminal Base Latitude
(2) MISC 23 - Terminal Base Longitude
(3) MISC 24 - "Pure Inertial" Latitude
(4) MISC 25 - "Pure Inertial" Longitude

3.2.1.9q(5) (continued)

(e) Upon INU shutdown, the last calculated mission RER, that is, the value when MISC 19 was last entered, shall be stored in the INU non-volatile memory for potential use in computing the cumulative CEP history, and shall be available for output to the display during the next ground alignment. During align, the value in MISC 19 shall never be recomputed. Insertion of data into MISC 19, 22, 23, 24 and 25 via the MISC PARAMETER INSERT function shall be inhibited. MISC locations 19, 22, 23, 24 and 25 shall be cleared on all Align-to-NAV transitions.

(f) If no mission RER is requested during a mission, or if "RER NA" was output when MISC 19 was last selected, the Operational Flight Program (OFP) will regard RER computation for that mission as invalid.

(g) Each time MISC 19 is selected, new mission RER computations shall take place, until MISC 20 (see paragraph 3.2.1.9q(6) below) has been selected. At that time the value in MISC 19 will remain until the next Align-to-NAV transition, or until cleared (see paragraph 3.2.1.9q(7) below).

(6) Cumulative CEP History. INU standard MISC PARAMETER READ Codes 20 and 21 shall be used to provide a recent history of navigation CEP performance.

(a) While in the NAV mode, entry of MISC 20 shall cause the cumulative CEP to be updated with the last valid mission RER (MISC 19), provided that the last mission RER is less than 3.1 nmi/hr. The output format for cumulative CEP shall be "X X.X", where the first character shall be the sample size N, which shall be less than or equal to 8, and the last two characters shall be the cumulative CEP to the nearest tenth nmi/hr.

(b) If the mission RER (MISC 19) was greater than or equal to 3.1 nmi/hr (Operator "Write-up" criteria for a single flight), the output of MISC 20 shall be "SQUAWK" in lieu of the cumulative CEP. In this case the mission RER (MISC 19) shall freeze, but no calculation of cumulative CEP will take place. This mission RER may be included in the cumulative CEP during the following alignment by entering a MISC 20.

(c) If the mission RER (MISC 19) was "RER NA", entry of MISC 20 would result in the same values as the last valid cumulative CEP calculation. That is, a new calculation will not be made. This applies to both the ALIGN and NAV modes.

3.2.1.9q(6) (continued)

(d) Entry of MISC PARAMETER READ Code 21 at any time results in the display of the Last Cumulative CEP computed using MISC 20. This MISC register is used for display only and does not cause any calculations to be performed.

(e) Only one cumulative CEP calculation may be made during a mission. In this case, a mission is defined as a NAV run that results in a valid RER calculation followed by an alignment.

(f) The computation of the cumulative CEP shall be in accordance with paragraph 6.2 contained herein. Reference on this subject is ASCC AIR STD 53/16, 24 Oct 1984.

(g) MISC regist[illegible]s 26 through 33 shall contain the last 8 mission RE[illegible] where the oldest RER is in MISC 26 and the most cur[illegible] is in MISC 33. The cumulative CEP calculati[illegible] shall include only the last 8 mission RERs. Therefore, when MISC 26 through MISC 33 are filled, new mission RERs into MISC 33 will "bump" old mission RERs out of MISC 26. These "bumped" values are no longer included in the CEP calculations, and are no longer available for display. The format of MISC 26 through MISC 33 shall be the same as that of MISC 19. Insertion of data into MISC 26 through MISC 33, and into MISC 20 via the MISC PARAMETER INSERT function shall be inhibited.

(h) Once MISC 20 displays "SQUAWK" as a result of meeting the operator "write-up" criteria for a single flight, the following tabulated reject criteria, as a function of the number of missions included in the cumulative CEP history (MISC 21), shall be used in determining whether the system has "failed" to meet specified navigation performance.

NO. MISSIONS	REJECT IF CEP
1	≥2.6 nmi/hr
2	≥2.1 nmi/hr
3	≥1.9 nmi/hr
4	≥1.8 nmi/hr
5	≥1.7 nmi/hr
6	≥1.7 nmi/hr
7	≥1.7 nmi/hr
8	≥1.6 nmi/hr

3.2.1.9q(6) (continued)

(i) Example of RER/CEP operation: Suppose that at the end of a flight the operator selects MISC 19 which equals "RER3.1" and then selects MISC 20. A "SQUAWK" will appear in the MISC 20 location alerting the operator to "write-up" the system. During the next alignment, maintenance personnel have the opportunity to include this last RER in the cumulative CEP if desired. The decision is made by examining:

MISC 19	(RER 3.1)
MISC 21	(history of CEP)
MISC 22-25	(Terminal Base/"Pure Inertial" coordinates to see if proper terminal position was used)

If it appears that this is truly a valid RER, then it is included in the CUM CEP by entering a MISC 20. If it appears that this was not a valid RER, then MISC 20 is not entered and this RER will not be included.

(7) Clearing Cumulative CEP history. Insertion of the word "ZERO" into MISC 21 where "ZER" are ASCII alpha characters and "0" is an ASCII zero will cause MISC 19 through MISC 33 to be cleared.

(8) Miscellaneous output data format. The output format for MISC 19 through MISC 33 displays (I07-30 through I07-32) shall be ASCII coded alpha numeric characters spaced as follows:

(a)

MISC 19	R	E	R	X	.	X
MISC 20 and 21	X			X	.	X
MISC 26-33	R	E	R	X	.	X

(b)

MISC 19	R	E	R		N	A
MISC 20	S	Q	U	A	W	K

(c)

MISC 22 and 24		D	D	M	M	T
MISC 23 and 25	D	D	D	M	M	T

where D - degrees
M - minutes
T - 1/10 minutes

(9) Retention of DEST WP/MP information. The DEST WP/MP table existing at turn-off shall be recallable in its exact form upon subsequent turn-on.

(10) INU ON/OFF Cycles. The number of INU on/off cycles accumulated since last INU repair shall be stored in MISC PARAMETER READ location 34.

3.2.1.9 (continued)

r. Baro-Inertial Altitude. The INU shall compute and output baro-inertial altitude. This altitude shall be generated from internally derived inertial data and externally derived pressure altitude. The baro-inertial altitude mechanization shall be optimized for vertical velocity accuracy and quick response during all flight situations. Short term inertial altitude shall be derived by double integration of vertical acceleration. Long term baro-inertial altitude shall be damped by pressure altitude. Baro-inertial altitude shall become valid 90 seconds after receiving valid pressure altitude (see I06/I08-22 Note 5 for definition of "valid pressure altitude"). The INU shall set the Altitude Loop Bit in the INU Control Word to logic "1" to signal that the baro-inertial altitude is invalid.

However, the INU shall not indicate an INU failure under this condition and shall continue to compute and output baro-inertial altitude. While in the align modes, the Altitude Loop Bit will be set immediately upon detecting that valid pressure altitude is not being received by the INU. While in the NAV mode, the Altitude Loop Bit shall be set upon detecting that valid pressure altitude has not been received for 5 seconds. The Altitude Loop Bit shall be re-set to logic "0" upon subsequent receipt of valid pressure altitude and baro-inertial altitude becoming valid. During periods that the INU is not receiving valid pressure altitude, the INU shall assume, for computation purposes, that the pressure altitude is equal to the internally derived inertial altitude. Thus, the vertical channel of the INU will track the accelerometers during this period. However, if this period exceeds 5 minutes, the INU shall assume, for computation purposes, that the pressure altitude becomes fixed at the baro-inertial altitude existing at the 5 minute point. Without respect to the time period that has elapsed since last receiving valid pressure altitude, the INU shall provide valid baro-inertial altitude outputs within 90 seconds of receiving valid pressure altitude. See the notes for Message F02 for additional information on vertical loop operation when F02 corrections are sent to the INU.

s. Miscellaneous Parameters Insert/Read. The INU shall provide the capability for storing/retrieving miscellaneous data via the miscellaneous parameter read and miscellaneous parameter insert functions (Appendix VI, Section I, FORMATS IX, X). This Miscellaneous Paramter storage shall, as a minimum, consist of the INU standard Miscellaneous Parameter data specified in Appendix VI. Miscellaneous Parameter functions may be expanded to include contractor unique Miscellaneous Parameter data.

3.2.1.10 Selectable Modes

The INU shall be capable of operating in the modes contained herein. These modes shall be selectable via the serial data bus, except the Standby (STBY) and Best Available True Heading (BATH) modes. Attitude (ATTD) mode is selectable via serial data bus or a hard-wired discrete input. Turn-on is a hard-wired discrete only. Discretes take priority over the serial data bus commands in all cases. Serial data bus mode commands shall have a 1 Hz filter in the INU to prevent inadvertent mode transitions which are possible with CDU rotary switches. Interfacing systems should monitor message I01-29 or I14-03 to verify INU mode transitions.

a. "ON/OFF" Mode. The INU will normally have power applied to it in the OFF mode. In the OFF mode, all input power shall be removed by the INU from internal INU circuits except for:

   (1) input EMI filter loads,
   (2) simple circuits required to respond to the turn-on discrete,
   (3) the INU battery charger circuit, and
   (4) the battery heater power.

   The INU can only be commanded OFF via the serial data bus or by removal of the INU turn-on discrete. After a shutdown has been initiated, power to the INU must remain on the INU for at least ten (10) seconds to allow time for the INU to store mission and maintenance data. During the INU power-down routine, a simultaneous loss of INU input power shall not cause an unrecoverable INU failure. If power is not left on for ten (10) seconds, a Stored Heading alignment may not be available. If the turn-on discrete is closed before power is applied, the INU may not turn-on, and it will be necessary to open and re-close the turn-on discrete in order to powerup the INU.

b. "STBY" Mode. Following powerup initialization, the system shall enter the "STANDBY" mode. The INU shall not enter any mode until a valid function select code has been received or the "ATTD" discrete has been set. The "STANDBY" mode is otherwise not a selectable mode. While in "STANDBY" mode, all navigation data outputs shall be set to zero, null or invalid as appropriate. All input messages shall be received and processed as required. The system shall respond to all mux bus data requests.

3.2.1.10 (continued)

c. "GC" Alignment Mode. This is the primary alignment mode. In this mode, present position shall be entered, then a gyrocompass alignment shall be performed in azimu-h to determine the vehicle true heading. During alignment, the .IU shall compute, and make available for display, an alignment status indication which shall be used for operator information only (see I07-19). The INU shall provide a "NAV RDY" indication (I06/I08-01 bit 16) when the INU can provide performance as specified in paragraph 3.2.1. Also, a "Degraded NAV RDY" indication (I01/I05/I06/I08-01 bit 6) shall be provided not later than the time specified in Table I so "NAV" can be entered (at the operator's option) to give a degraded performance rapid gyrocompass capability. See Figure 3.2.1.10-1.

(1) Degraded Performance. Two types of degraded performance "GC" alignments shall be available:

(a early ction of the "NAV" mode during the egraded NAV RD dication, and

(b) full "G alignment to the previc s flight terminal position.

Insertion of present position to 1 arc-minute accuracy within two minutes of start of align shall result in full GC performance eight minutes after start of align. Should present position be entered after two minutes of start of align, the alignment shall be restarted and full GC performance is obtained eight minutes after insertion of present position.

Failure to enter present position shall result in an alignment to the "inertial display" position stored from the previous flight and may result in degraded performance.

ompletion of this alignment mode shall be signaled via a bit in an INU Control Word (I06-01 bit 11). The INU shall continue to transmit the align time and status in effect at he time of transition.

3.2.1.10c (continued)

(2) Interrupted Align/Enhanced Interrupted Align (EIA).

(a) Interrupted Align. The INU shall incorporate an Interrupted Align capability to enhance the functional operation of ground alignment. This capability shall allow the operator to interrupt normal GC Align operation, taxi the aircraft to a different position, and resume the suspended alignment without degradation of initial Heading and Attitude performance. Time in Align (MISC 63) will not increment during this period of interrupted alignment, but will continue to increment from the time of interruption after alignment has resumed.

Transition to Interrupted Align shall be allowed anytime after "Degraded NAV RDY" (within 1.5 minutes) indication is provided I06/I01-01 bit 6. Transition from GC Align to Interrupted Align shall be accomplished by selection of NAV mode via the D01-01 Function Select Code (FSC) or by auto-mode transition, consistent with paragraph 3.2.1.9o.

Alignment shall be resumed by one of the following operator initiated actions:

(1) If the transition to Interrupted Align was accomplished by selection of NAV mode via FSC, then alignment is resumed by selecting GC Align via FSC.

(2) If the transition to Interrupted Align was accomplished by auto-mode transition, then alignment is resumed by initially selecting NAV mode via FSC and then selecting GC Align via FSC.

A ground speed in excess of 80 knots shall disable the Interrupted Align capability, and any subsequent selection of GC Align via FSC shall result in a full restart of GC Alignment. Failure by the operator to enter a present position shall result in a realignment to the current "inertial display" position and may result in degraded GC performance. Insertion of a present position by the operator within the initial two minutes following reselection of GC Align via FSC shall result in full GC performance eight minutes after alignment restart. Operator entry of a present position after the initial two minutes following reselection of GC Align via FSC shall result in a full restart of GC Align with full GC performance in eight minutes.

3.2.1.10c(2) (continued)

(b) Enhanced Interrupted Align (EIA). In addition to its functional benefits, Interrupted Align shall provide enhanced performance in accordance with Table I when the following conditions are met:

(1) The INU will complete a full performance GC Alignment.

(2) The vehicle shall be taxied in NAV mode to a new heading at least 70 degrees different from the heading used for the initial GC Align. The taxi time shall not exceed 10 minutes.

(3) After the taxi maneuver, GC Align shall be continued for a minimum of four minutes. The aircraft must be completely stopped before entering GC Align and remain stopped throughout the duration of the second alignment.

(4) The maximum vehicle constant acceleration from take-off through the first five minutes of flight is 3.5 fps^2. The maximum vehicle acceleration for the first 10 seconds of take-off roll is 13.0 fps^2. The maximum peak acceleration after the first 10 seconds of take-off roll through the first five minutes of flight is 7.0 fps^2.

Since the full GC performance accuracy is available during the second alignment, "NAV Ready" shall be true throughout the second alignment.

```
   : ≥ 8 minutes : 10 minutes (max) : ≥ 4 minutes : ____
   :-------------:------------------:-------------:------
   :   ALIGN     :       NAV        :   ALIGN     : NAV
   :             :                  :             :
power-up              taxi                  take-off
```

Note: Interrupted Align can provide enhanced INU performance, but the INU can only guarantee performance in accordance with Table I when steps (1) through (4) (above) are followed.

Note: EIA alignments will not be separated from the normal GC alignments for the CEP calculation in Miscellaneous parameters 19, 20, 21, and 26 through 33.

A full performance EIA, in accordance with paragraph 3.2.1.10c(2)(b)(1) through (4) shall indicate eight (8) minutes time-in-align at the end of the first alignment. Upon completion of the second 4-minute alignment, the align time is to be twelve (12) minutes. If the operator fails to complete the requirements of steps (1) through (4) above, full EIA performance may not be provided and reselection of GC shall result in a continuation of the normal GC align with normal performance expected.

3.2.1.10 (continued)

d. "SH" Alignment Mode. In this fast alignment mode, the INU shall level to local vertical and align to the last stored heading and position. As a prerequisite for a stored heading alignment, the vehicle is spotted and a complete gyrocompass alignment is performed before the INU is shut down. Shutdown must occur while still in the gyrocompass alignment mode. The vehicle shall not be moved prior to the next alignment. If the INU determines that the aircraft has been moved, it shall transition to the GC align mode. Failure to meet the prerequisites shall cause the INU to revert to the BATH alignment mode as defined below.

A degraded NAV RDY indication shall be provided when the NAV mode can be entered with degraded performance. A full performance NAV RDY indication shall be provided when the INU will provide performance as specified in paragraph 3.2.1. Entry of heading or present position while in this mode shall cause the INU to revert to a BATH alignment mode as defined below.

If the INU is doing a valid Stored Heading alignment but remains in the SH mode long enough to do a full GC alignment, the INU shall use the best available source of data. (See Figure 3.2.1.10-2)

e. "BATH" Alignment Mode. The Best Available True Heading (BATH) alignment mode is a sub-mode of the "SH" alignment mode and is not a selectable mode. The "BATH" alignment mode can only be entered via one of the following methods:

(1) When the prerequisites for the "SH" alignment mode have been satisfied, insertion of True Heading, Mag Heading, or present position shall cause the INU to revert to the "BATH" alignment mode.

(2) When the prerequisites for the "SH" alignment mode have not been satisfied, selection of the "SH" alignment mode shall result in the INU initiating a "BATH" alignment to the heading and present position stored from the previous flight.

3.2.1.10e (continued)

Heading and/or present position may be updated in any order and at any time during the alignment. Initiation of the "BATH" alignment mode shall provide a quick reaction, degraded performance alignment with performance in accordance with Table I when the INU has completed a "BATH" alignment. If a full performance "NAV RDY" indication has been achieved, reversion to the "BATH" alignment mode shall cause the "NAV RDY" indications to change to a degraded "NAV RDY" indication.

f. "NAV" Mode. This is the primary flight mode of operation and it shall be entered (from ground alignment) by either of the following two methods:

(1) Operator selection of NAV mode via FSC; or

(2) Auto-mode transition in accordance with para 3.2.1.9o.

In either case, if ıe NAV mode is entered prior to the INU's ability to support .e NAV mode with MAG HDG GOOD (see Figure 3.2.1.10), then the INU shall switch to the ATTITUDE mode and reset the heading discrete to indicate MAG HDG BAD, without storing a fault in the fault table. If a feature is mechanized that refines/trims ISA tilt and/or bias errors while in the NAV mode, it shall be known as a Navigation-Alignment Refining Feature (NARF). Any auto-transition to this feature while in the NAV mode shall be recorded in the Record of NAV Events. The NARF shall not prevent the performance of EIA or auto-mode transition provided normal alignment criteria of para 3.2.1.10c(2) have been otherwise satisfied. Actual time that the INU is in this feature shall increment in MISC 100 and be excluded from ALIGN-TIME (MISC 63) and TIME-IN-NAV (MISC 65). The NARF shall be disabled if a "1" is entered into MISC 99 during the alignment mode and, in the NAV mode, if the ground speed is equal or greater than 80 knots. MISC 99 shall be reset to logic "0" upon the next power cycle.

g. "UPDATE" Modes. In the update modes, the INU shall be capable of accepting corrections for selected system quantities from external sources via the data bus. This update capability will be available for the quantities available in F02 for "Auxiliary" and "Air Align" updates (see Format Section V of Appendix VI) and via D01 message for "Overfly Fix" updates. If commanded from an outside source (via the data bus), the INU shall be able to apply these corrections and provide an acknowledge signal to an outside source (via the data bus). The Control Vector Acknowledge Bit (I01-01 bit 8) shall be set high within 35 milliseconds following reception of the F02 correction vector. Orthogonalization shall be the responsibility of the user. The following three update modes shall be available:

(1) "AIR ALIGN". The INU, in conjunction with external sensor information, via the F02 correction vector (generated by an external computer), shall be capable of performing an inflight alignment having had no ground alignment, partial ground alignment or a complete gyro compass alignment. This same mode shall provide the capability for performing "aided" navigation (i.e., automatic update). The Control Vector Acknowledge Bit (CVAB) shall be set to acknowledge receipt and application of the data contained in the F02 message. This bit shall be reset 40 to 80 milliseconds after being set. Refer to Figures 3.2.1.10-4 and 3.2.1.10-5.

(a) "COLD START AIR ALIGN" Upon entry into the "AIR ALIGN" mode, the INU shall perform initialization and coarse leveling. Upon completion of coarse leveling, "Attitude Ready" (I06-01 & I01-01 bit 7) shall be set indicating that the INU is ready to accept F02 corrections. F02 corrections may be sent prior to "Attitude Ready", but the INU will discontinue leveling and "Attitude Ready" will not be set (INU leveling must be completed via F02 corrections).

"HOT START AIR ALIGN" If Initialization and coarse leveling have been accomplished prior to entry into the "Air Align" mode, "Attitude Ready" will be set immediately upon entering "Air Align" mode.

(b) Any output position differences computed while in the "AUXILIARY" or "OVERFLY" update modes shall be zeroed prior to applying the F02 correction.

(c) The INU will accept and apply F02 corrections at a maximum rate of 5.0 Hz.

(d) When entering the "AIR ALIGN" mode from a previous operating mode (i.e., HOT START), the INU status flags in I06-01 and I01-01, and the "Attitude Good" and "Magnetic Heading Good/Bad" analog output discretes shall remain unchanged from the previous mode, and all other discretes shall be set consistent with entering the "NAV" mode, until reception of an F02 with the filter mode bit set.

(e) While in the "AIR ALIGN" mode and after reception of an F02 with the filter mode bit set, the INU status flags and analog output validity discretes shall be consistent with the status of the "ALL NAV DATA GOOD" flag (F02-01 bit 3), unless invalidated by INU detected failures. Exiting the "AIR ALIGN" mode to any other navigation mode shall not effect the INU status flags or analog output discretes. Also see F02-01, Note 1.

3.2.1.10g (continued)

(2) "AUXILIARY". The INU shall be capable of accepting suitable position update data from outside sources such as radar, TACAN, and GPS via the data bus. Operator intervention shall be required to either accept or reject the update (i.e., semi-automatic update). F02 deltas shall be the difference between the outside source position and the "pure inertial" position. The INU shall recreate outside source position by summing the F02 deltas to the "pure inertial" position. The INU shall then output position differences computed by subtracting the "display" position from the outside source position. An operator accept decision shall cause these differences to be applied to the current "inertial display" position. "Pure inertial" position shall be transmitted, as INU Miscellanous Data, upon receipt of an appropriate "MISC PARAMETER READ" request.

(3) "OVERFLY". The INU shall be capable of being updated manually by overflying a known position. The following mechanization shall be used: Subsequent to selection of the overfly function, and upon receipt of either a digital update command or a 28 VDC designate update discrete, position fix deltas shall be computed between the "display" position and a known position stored in the selected destination Waypoint/Markpoint location in the INU memory. These output position differences shall be transmitted via the data bus for display and operator accept/reject decision. Selection of alternate Waypoints/Markpoints (destinations), or insertion of new position information in the selected destination prior to receipt of the accept/reject command, shall cause new output position differences to be computed relative to the redefined known position and the new output position differences shall be transmitted for display and operator accept/reject decision. Upon receipt of an accept command, the output position differences relative to the latest selected destination shall be applied to the "display" position. "Pure inertial" position shall not be updated using this update mode. "Pure inertial" position shall be transmitted as INU Miscellaneous Data upon receipt of an appropriate "MISC PARAMETER READ" request.

h. "CAL" Mode. A vehicle self-calibration mode shall provide for automatic calibration of the azimuth component of gyro bias drift, in addition to the gyro bias drift terms calibrated during the alignment mode. The "CAL" mode shall require no more than 90 minutes to complete, and shall include provisions for updating the affected calibration constants stored in the INU. Systems which do not require calibration more frequently than 18 months are not required to mechanize the "CAL" mode. If the "CAL" mode is not mechanized in a system, the INU response to a commanded "CAL" mode shall be setting of an Illegal Command bit in an appropriate serial digital word. The "CAL" mode shall be initiated by a bit in a serial digital word and shall require no external inputs other than vehicle present position for operation. It shall operate in the ground alignment environment, without the need for any Support Equipment (SE), and shall provide a status indication for output. No manual insertion of calibration data shall be required by the Organizational or Intermediate Level personnel, either after calibration or at any other time, for proper operation of the system. Performance history (see 3.2.1.9q) shall be automatically re-initialized at the completion of the "CAL" mode. Excess time over ground alignment may be used to provide incremental calibration of the platform.

i. "ATT" Mode. The attitude mode is a back up mode mechanized as a leveling mode entirely within the INU. It shall be capable of being initiated either by the INU computer or by external control. The attitude mode shall be able to be initiated while the INU is moving or stationary and thereafter shall provide a stable reference frame for generation of roll, pitch and inertial heading angles. Upon selection, the INU will reinitialize the Attitude, and not use the existing Attitude solution at the time of transition. See Figure 3.2.1.10-6.

j. "TEST" Mode. The "TEST" mode shall incorporate functional performance tests, fault detection, and fault localization checks. It shall be initiated by a bit in a serial word in conjunction with appropriate function and/or data select codes, and shall proceed automatically with no other requirements for external equipment or operator action. Entry into the test mode shall only be allowed from the STANDBY and ORIENT modes. If the TEST mode function select code is received after some other mode has been selected, the INU shall maintain the previous mode and shall not initiate the TEST mode. If, while in the TEST mode, a valid mode other than TEST is selected, the INU shall immediately switch to the new mode. Entry into the TEST mode shall not be allowed unless CADC True airspeed is invalid or if True airspeed is valid and less than 80 knots. ORIENT mode shall be entered before the TEST mode for other than the default condition. The combined capabilities of the "TEST" mode, the system Built-In-Test (BIT) and other operator observable conditions (e.g., results of in place navigation runs) shall have a 95% confidence level in fault detection on the vehicle, with the false alarm rate not to exceed 2%. The TEST mode shall be exercised with the INU stationary in the ground environment. It shall not require removal of the INU from its mount in the vehicle. While it is operating, the TEST mode shall provide system status indications for output.

3.2.1.10 (continued)

k. "GRID" Mode. A grid steering mode shall be implemented to compute grid heading from inertially derived true heading and a manually inserted convergence factor. The grid mode shall be manually selected. If a convergence factor is not entered by the operator, grid heading shall be computed using either a convergence factor of 1.0 or the INU computed convergence factor. Entry into the grid mode shall be enunciated. INU MAG heading outputs (digital and analog) shall be replaced by grid heading in this mode and it shall be possible to readout both true and grid heading during grid operation. Reversion to the normal steering mode shall be possible at any time without system degradation.

l. "ORIENT" Mode. This mode shall provide the capability to mount the INU in any valid orientation and to allow software boresighting. This mode shall be selectable over the serial data bus only in accordance with 50.1.1 and shall supersede all other optional Orient and boresight functions. Definition of this mode is contained in paragraph 50.5.5.2.1. Initialization of orient/boresight shall be carried out upon every INU turn-on. Entry into the ORIENT mode from other than the STANDBY mode shall result in illegal command indication.

3.2.1.11 Data Output

The INU shall output the signals specified in Appendix II during the "NAV" and "GRID" modes when applicable. During the "CAL" and "ALIGN" modes, the gyro and accelerometer parameters which are updated shall be available in a serial digital data stream. The INU shall output signals as detailed in Table VI-6.

3.2.1.12 Validity Output Discretes

The INU shall provide output discretes that define the validity of the analog output signals of roll, pitch, and magnetic heading.

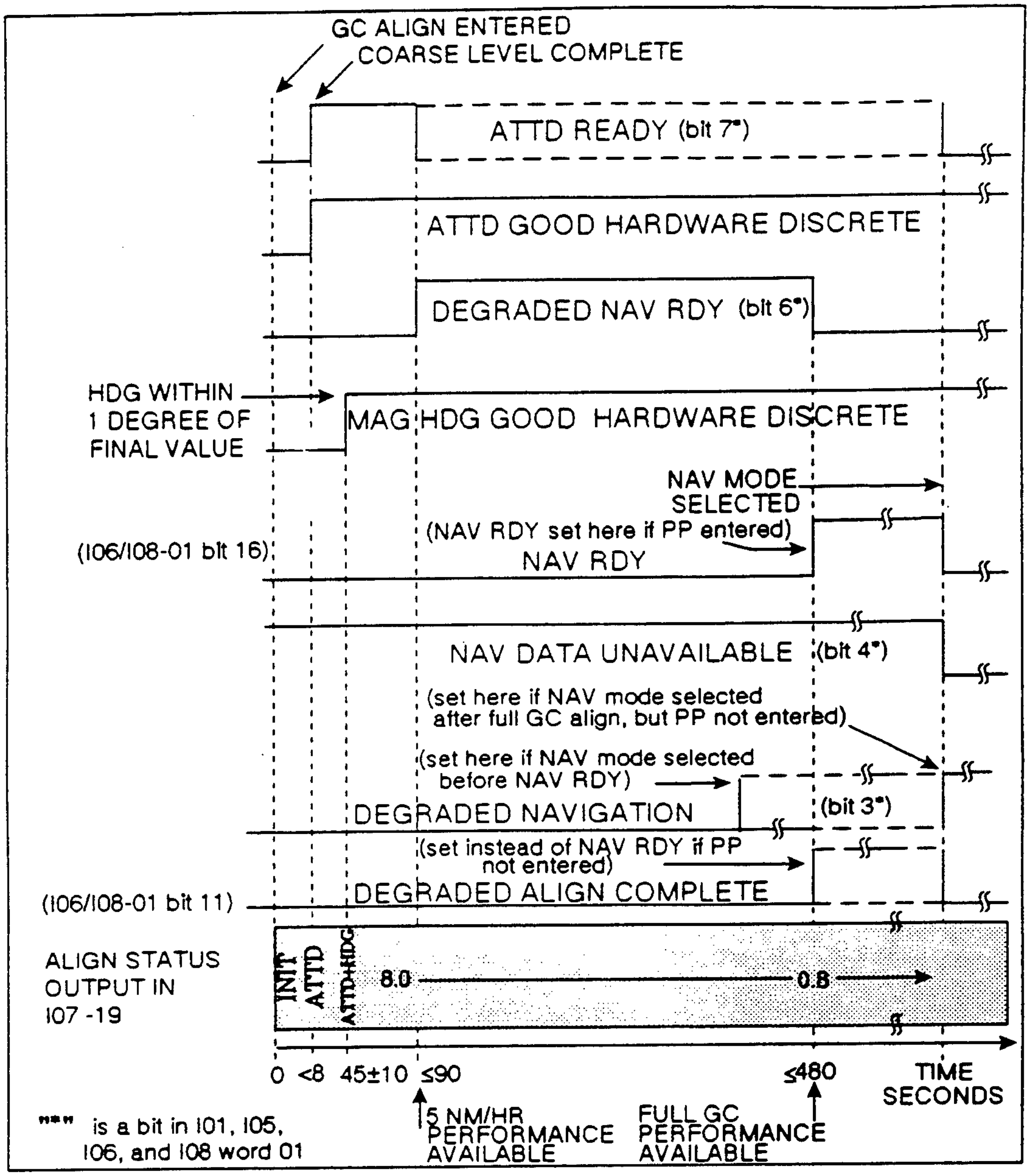
a. Attitude Good. The discrete that defines the validity of the roll and pitch analog output signals shall be set true (28 VDC) in the align, navigate, and attitude modes whenever the INU has completed coarse leveling (the established vertical is ≤ 1 degree of uncertainty). Operating performance shall be as specified in Table I. The discrete shall be set false (open circuit) for any malfunction that would prevent the INU from maintaining a vertical reference or cause invalid analog output roll and pitch signals. The discrete shall not be affected by normal 400 Hz power interrupts which are consistent with MIL-STD-704A (50 ms as shown in limit 3, Figure 3). The discrete shall be fail-safe to the false state.

b. Magnetic Heading Good. The discrete that defines the validity of the magnetic heading output signal shall be set true (28 VDC) in the align and navigate modes whenever the INU has established heading within one degree of uncertainty. The discrete shall be set false when magnetic heading is invalid. However, flight north of latitude 72N or south of latitude 60S shall not be the basis for setting this discrete false. The discrete shall not be affected by 400 Hz power interrupts which are consistent with MIL-STD-704A (50 ms as shown in limit 3, Figure 3). The discrete shall be fail safe to the false state.

c. Magnetic Heading Bad. This discrete maintains the opposite state of Magnetic Heading Good at all times.

3.2.1.13 Data Latency

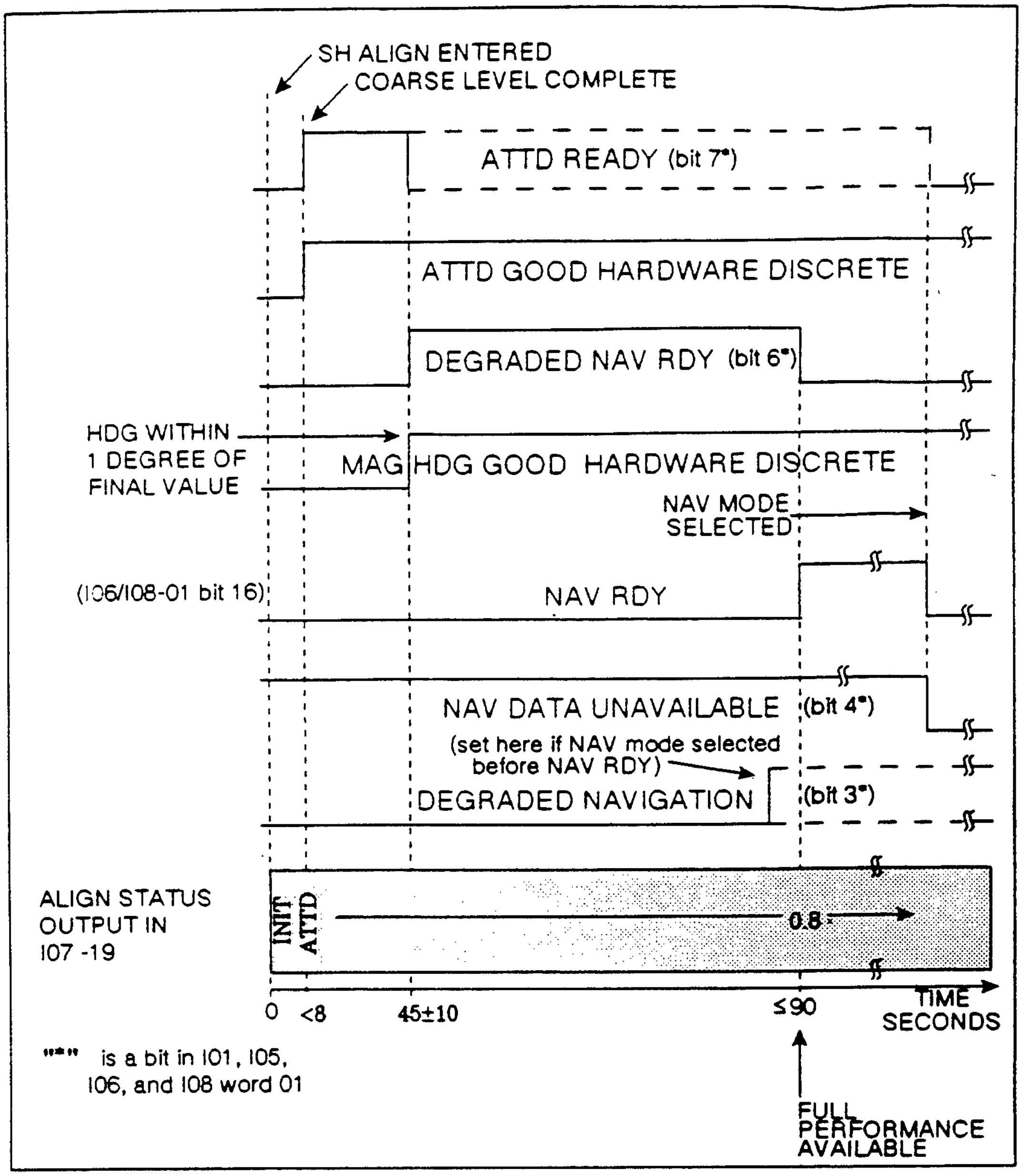
Data Validity and Response Time must meet the requirements specified in Table I.



- PP may be entered within 2 minutes with no effect on align time. After 2 minutes, entering PP will cause alignment to restart.

- If PP is not entered, CDU display alternates between the code for 'INIT' and the code for the current value of align status until entered.

Figure 3.2.1.10-1
Gyrocompass Alignment Time-Line



- Testing for movement of the aircraft is performed between 45 and 90 seconds.

- This time-line assumes:
    - SH was set-up (refer to 3.2.1.10.d).
    - Aircraft was not moved after set-up.
    - PP was not entered.
    - Heading was not entered.

If assumptions are not true, the BATH mode is entered.

Figure 3.2.1.10-2
Stored Heading Alignment Time-Line

Figure 3.2.1.10-3
BATH Alignment Time-Line

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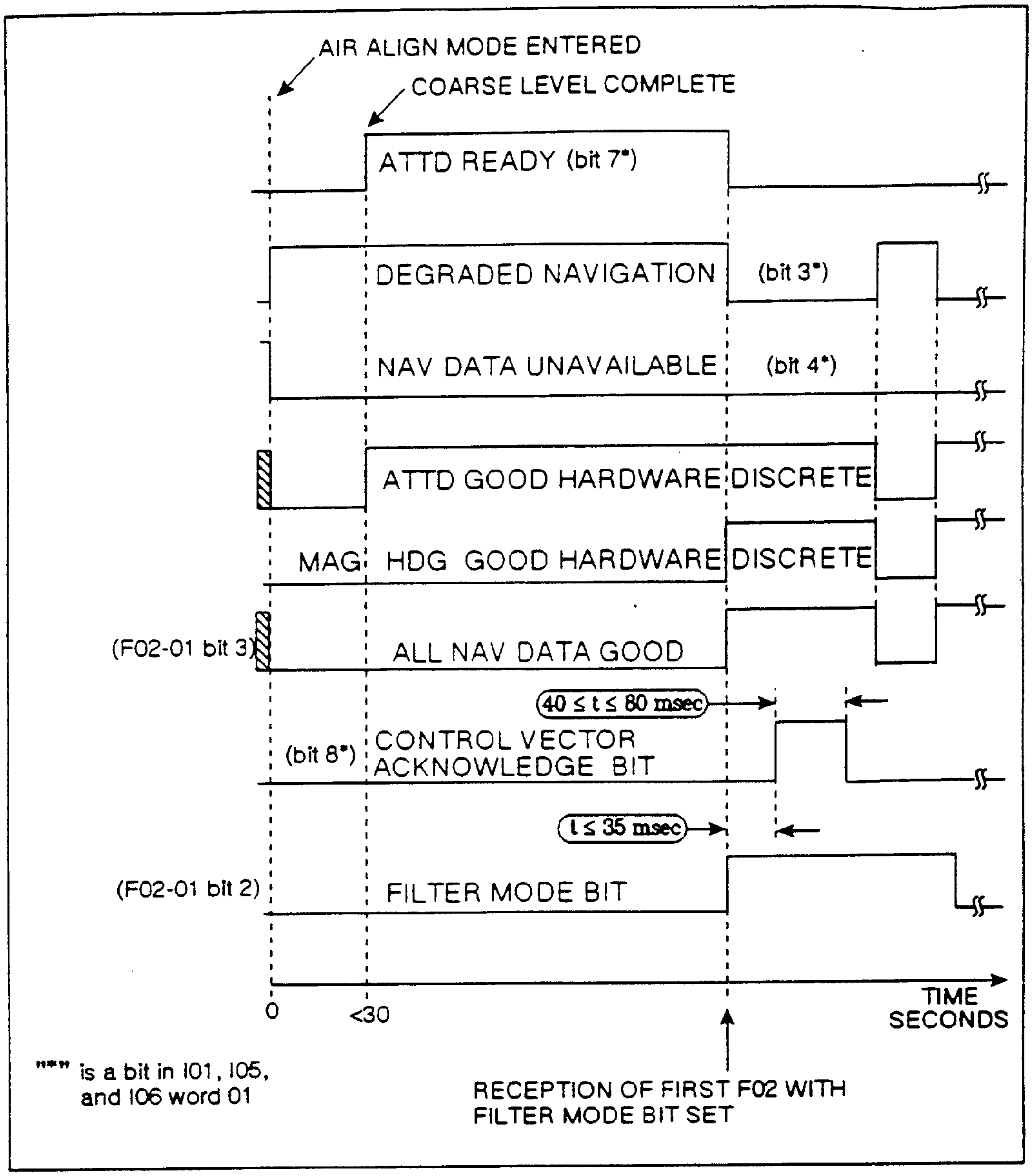


- This time-line is valid if the Air Align mode is selected prior to the time that the INU can support navigation.
- It is the user's responsibility to not apply F02 corrections until Coarse Level complete. F02 corrections received at any time will be applied.
- MAG HDG GOOD and ATTD GOOD discretes will always echo the ALL NAV DATA GOOD BIT unless a BIT failure is detected.
- DEGRADED NAVIGATION will always echo the complement of ALL NAV DATA GOOD BIT.
- If the Air Align mode is deselected, the discretes will remain in the last state consistent with the last state of the ALL NAV DATA GOOD BIT.

Figure 3.2.1.10-4
Cold Start Air Alignment Time-Line

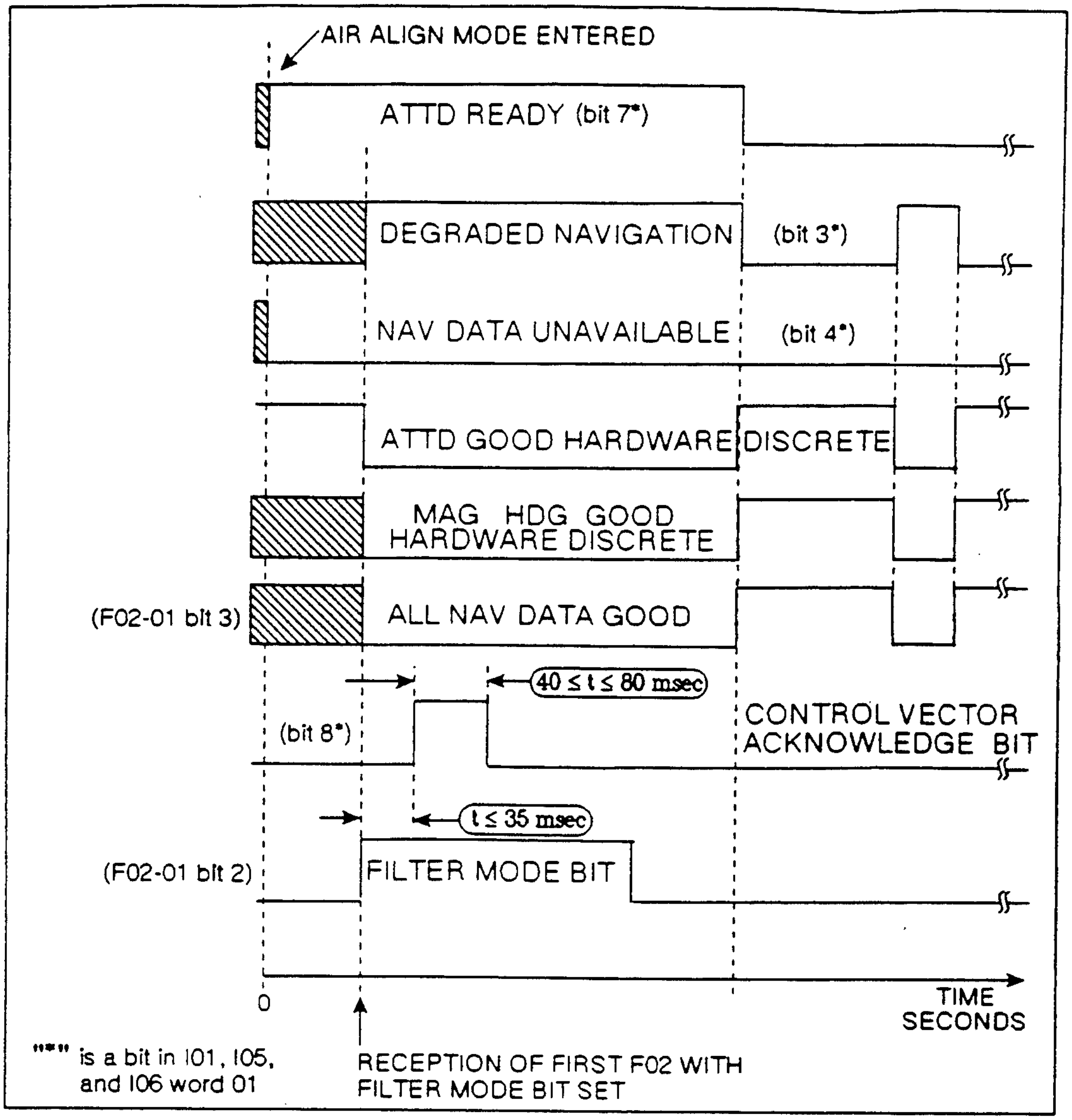


Figure 3.2.1.10-5
Hot Start Air Alignment Time-Line

NOTES FOR THE HOT START AIR ALIGNMENT TIME-LINE (Figure 3.2.1.10-5 cont)

This time-line is valid if the Air Align mode is selected after the time that the INU can support navigation.

Maintaining current validity status upon Air Align mode entry and prior to receipt of an F02 update prevents inadvertent loss of valid NAV data caused by merely selecting the Air Align mode.

MAG HDG GOOD and ATTD GOOD discretes will echo ALL NAV DATA GOOD BIT after first F02 received with FMB set unless a BIT failure is detected.

DEGRADED NAVIGATION BIT will echo the complement of ALL NAV DATA GOOD BIT after the first F02 is received with FMB set.

If the Air Align mode is deselected, these discretes will remain in the last state of the ALL NAV DATA GOOD BIT if an F02 correction has been applied. Otherwise, they will remain as they were before the Air Align mode was entered.

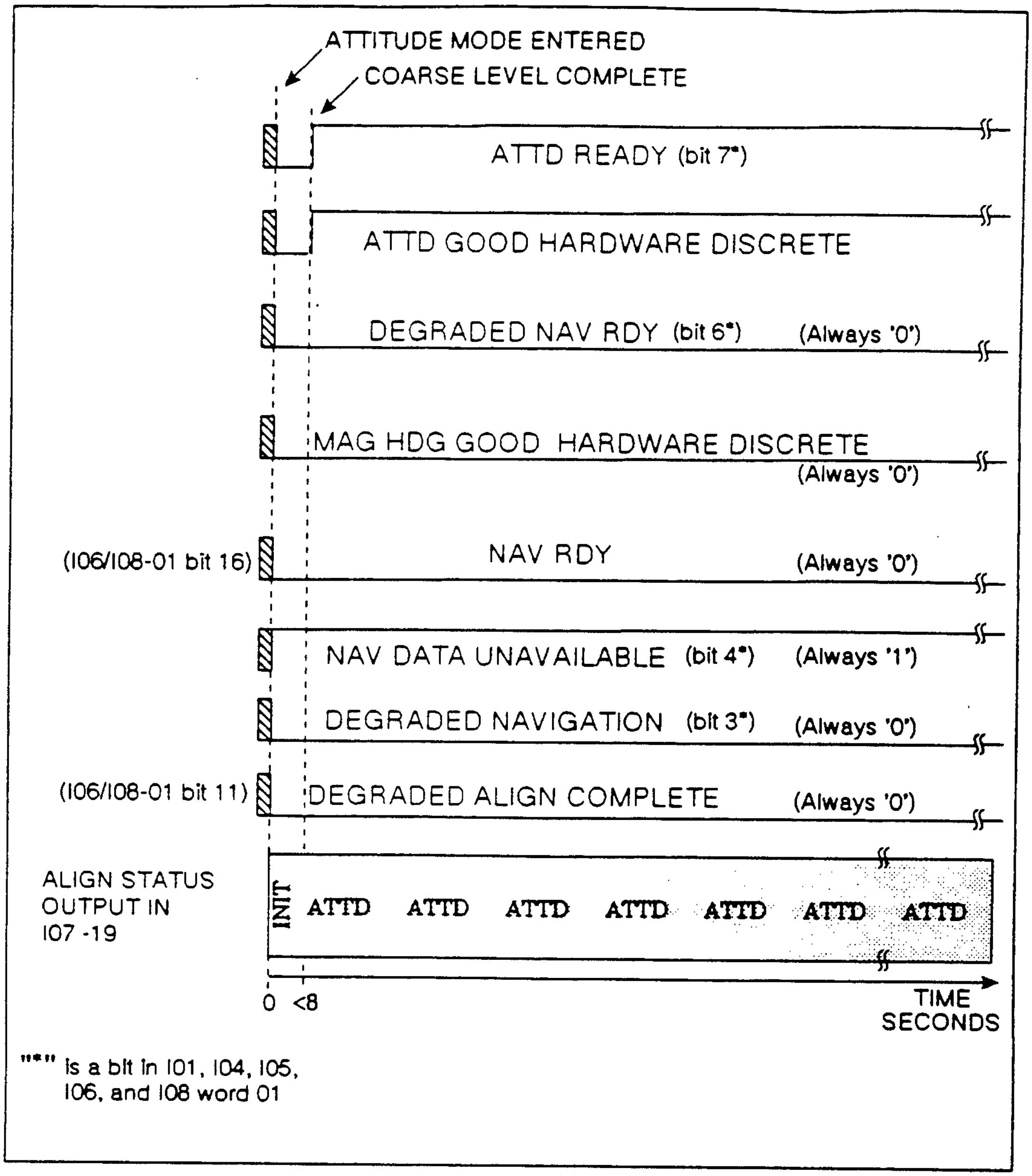


Figure 3.2.1.10-6
Attitude Mode Time-Line

3.2.2 Physical Characteristics

3.2.2.1 Size

The INU shall comply with the form factor dimensions and tolerances as set forth in Appendix IV of this specification.

3.2.2.2 Electrical Interface

Figure 2 and Figure 2A establish the electrical interface for the INU. They define the signals by pin assignment.

3.2.2.3 Electrical Power

The INU shall operate with electric power having the characteristics specified by MIL-STD-704 for Category B equipment. The INU shall receive 26 volts, 400 Hz single phase synchro reference power in accordance with Figure 2A and Table II. INU performance and utilization of power shall be in accordance with MIL-STD-704 and the following:

a. The INU shall provide performance as specified herein when supplied electric power having the characteristics specified by MIL-STD-704 for the normal, abnormal and emergency modes of electric system operation. The applicable units for steady state and transient voltage and frequency are as follows:

(1) AC POWER

115/200 Volts, 400 Hz (nominal)
Steady state voltage - 104 to 122 Volts
(includes normal and emergency limits)
Steady state frequency - 360 to 440 Hz
(includes normal, abnormal, and emergency limits)
Transient voltage - limits 1 and 4, Figure 3, MIL-STD-704
(includes normal and abnormal limits)
Transient frequency - limits 1 and 4, Figure 5, MIL-STD-704
(includes normal and abnormal limits)

(2) AIRCRAFT 28 VOLTS DC DISCRETE POWER

28 Volts (normal)
Steady state voltage - 16 to 30 Volts
(includes normal, abnormal, and emergency limits)
Transient voltage - limits 1 and 4, Fig. 9, MIL-STD-704
(includes normal and abnormal limits)
This power source (Pins 5 and 6 of P-132) provides voltage to power the 28 Volt switching discretes; i.e. - ATT GOOD, MAG HEADING GOOD, MAG HEADING BAD

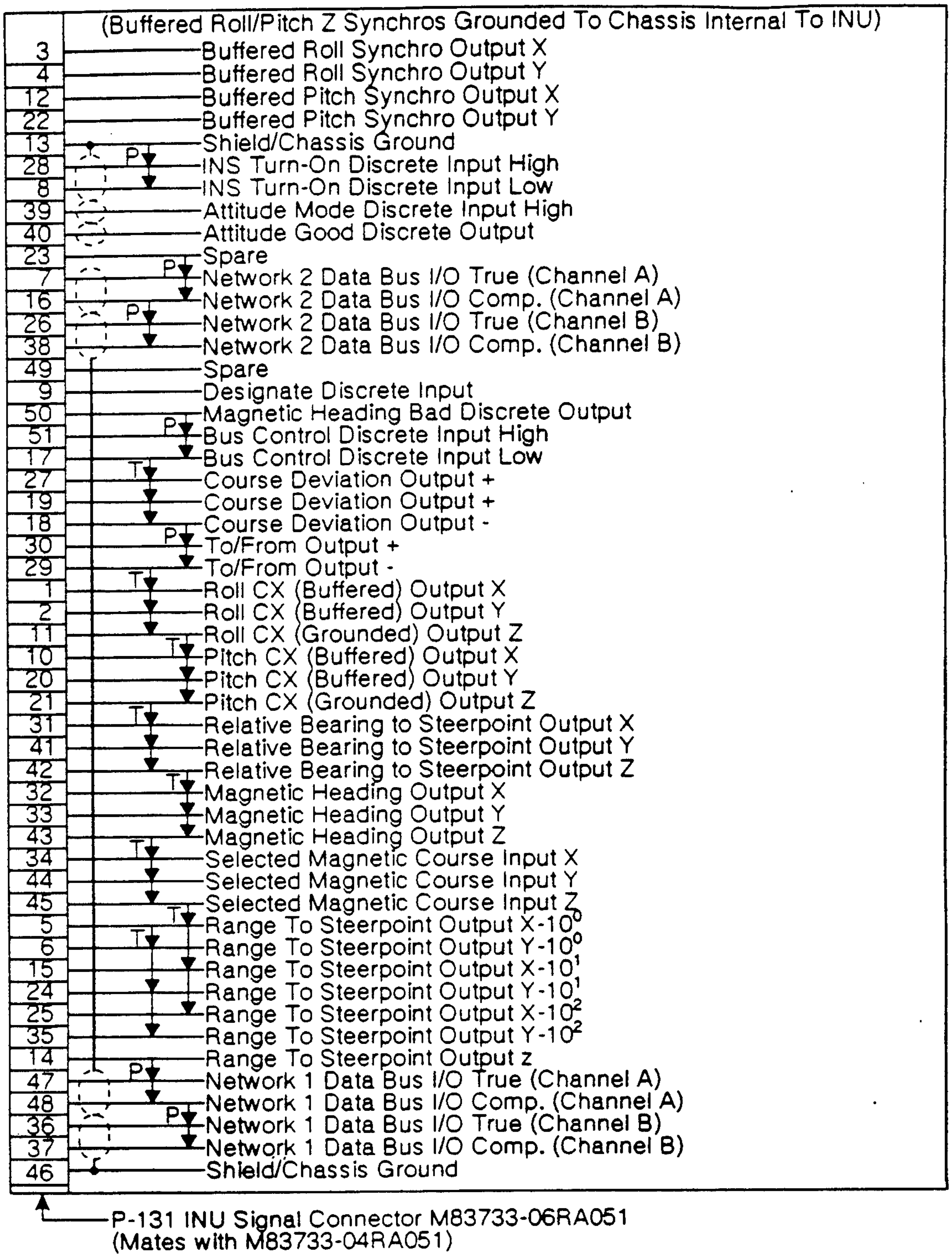
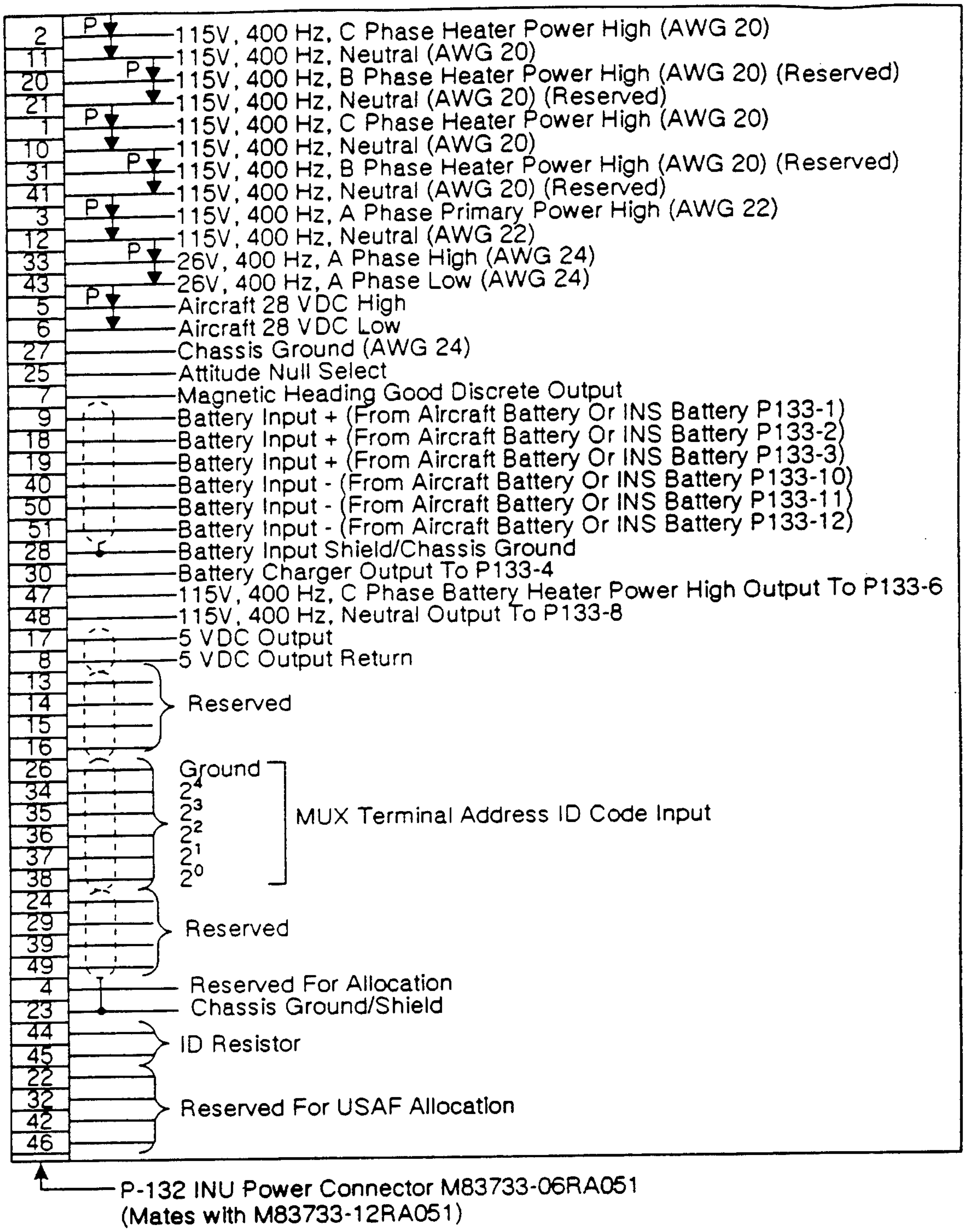


Figure 2
Electrical Interface



BATTERY CONNECTOR (F-16) → MS27467T11F35S

BACKSHELL → MS27506F10-2

Figure 2A
Electrical Interface

3.2.2.3 (continued)

b. The INU shall not be damaged when subjected to the steady state AC abnormal limits of MIL-STD-704. The INU shall be capable of returning to full performance operation subsequent to an abnormal power transfer from an emergency power generator system to the main power system. The required transfer conditions are described as follows:

(1) Coast down of the generator, to the point of transfer of the bus, requires 0.5 to 1.0 seconds. During this period, frequency of the AC voltage decreases linearly from 400 Hz to 275 Hz ± 25 Hz. The AC voltage drops from 115 volts at 400 Hz to 85 volts at the point that transfer is initiated. During transfer the voltage is zero for 0.002 to 0.005 seconds.

(2) The INU shall operate continuously when supplied with Phase A prime power only. Specified performance shall be maintained for at least five minutes in the absence of Phase B and Phase C heater power.

c. The INU shall not be damaged by the loss of one or more phases of AC power or by the total loss of power at any input terminal.

d. Battery Power Supply. The INU shall be capable of operating from battery power during aircraft 400 Hz phase A prime power interrupts.

(1) INU Requirement. The INU shall perform as specified herein when interfacing with a battery bus which has the following DC power supply characteristics.

(a) Power. The battery bus voltage is a nominal 28 volts with a minimum and maximum value of 16 VDC and 30 VDC, respectively.

(b) AC Ripple. The maximum allowable AC ripple voltage vs frequency is shown in MIL-STD-704, Figure 7.

(c) Line Transients. The line transients at the INU Battery input terminals are in accordance with MIL-STD-704, Figure 9, Curves 5 and 6.

(2) INU DC BUS Isolation. Electrical isolation (greater than 10 million ohms) shall be provided between the positive voltage battery BUS and the INU positive 28 VDC input terminals.

(3) DC Voltage Drop Out. If, during any mode of operation, the INU has transferred to battery power because of a 400 Hz phase A prime power failure, the INU shall monitor the bus voltage.The INU shall initiate an orderly shutdown whenever the battery steady state voltage drops below 16.0 ± 0.5 VDC.

3.2.2.3d(3) (continued)

(4) Battery Trickle Charge. When operating, the INU shall deliver at least 25 but not more than 50 milliamps rectified 400 Hz current to the battery charging circuit (connector J-132, pin 30; see Figure 2A).

(5) Battery Heater Requirements. The INU shall provide heater power at connector J-132, pins 47 and 48 (see Figure 2A). The maximum heater power shall not exceed 241 watts.

e. The INU shall provide a 5 VDC output power supply source for use by external equipment. The intent of this source is to provide power for strapping to the Bus Control Discrete input for inhibiting the Bus Control Function of the INU. This power source shall be regulated to ±10%, current limited to 500 ma, and short circuit/polarity protected (connector J-132, pins 8 and 17; see Figure 2A).

f. The INU AC power consumption shall not exceed that described in Table II.

Table II - INU AC Power Consumption Summary

Vehicle Power	Starting	Running	Power Factor
115 V, 400 Hz, 1 Phase A INU Power (Aircraft Essential Bus)	340 VA	280 VA	(1)
Phase B (RESERVED)			
115 V, 400 Hz, 1 Phase C Heater	300 VA (2)	70 VA	(1)
26 V, 400 Hz, 1 Phase (Supplied through transformer from Prime Power Phase)	5 VA	5 VA	(1)

Notes: (1) Reference MIL-STD-704A, Figure 12.
(2) Includes 241 watts maximum throughput for battery heater power

3.2.2.3 (continued)

g. The INU DC power consumption shall not exceed that described in Table IIa.

Table IIa - INU DC Power Consumption Summary

	Running
Aircraft Signal Power	(Note 1)
Battery Power	240 watts maximum (Note 2)
Note 1: Aircraft 28 VDC discrete signal power is required during AC powered operation, to provide ATTITUDE Good, Mag HDG Good, and Mag HDG Bad.	
Note 2: Battery power is required only during loss of AC power to the INU.	

h. Performance While Operating on Battery. When the 115 Volts AC is not present and the INU is operating steady state from the battery, the INU shall provide navigation data continuously with accuracies specified in Table I. Analog outputs as defined in Appendix III are unavailable.

3.2.3 Reliability

The reliability of the Standard INU shall have a minimum predicted MTBF of 2600 hours in accordance with MIL-HDBK-217D analysis. The prediction shall be conducted using an airborne inhabited transport environment at 50 degrees Celsius plus internal rise temperature. Cooling air shall be assumed to be at a flow rate of 1.5 pounds per minute at 38 degrees Celsius.

3.2.3.1 Reliability of Replacement and Spare SRU/Modules

The reliability of Replacement SRU/modules and spare SRU/modules shall not result in a degradation of the INU reliability.

3.2.4 Maintainability Program

The contractor shall develop and follow a maintainability program in accordance with MIL-STD-470 and this specification.

3.2.4.1 Design

The maintainability of the INU shall be a prime consideration during equipment and installation design. The Built-In-Test (BIT) functions, provisions for test points, packaging, and modular design features shall be in accordance with MIL-STD-415 and this specification. The INU, including BIT provisions, shall be designed to meet the quantitative maintainability requirements of paragraph 3.2.4.2 herein.

3.2.4.1.1 Calibration Interval

The time between required calibration shall be greater than 60 days if the "CAL" mode is mechanized (see paragraph 3.2.1.8g) or greater than 18 months if the "CAL" mode is not mechanized. If the "CAL" mode is not mechanized, the bit in the serial word that initializes the "CAL" mode shall cause an illegal command bit to be set in the INU to CDU message.

3.2.4.1.2 Maintainability Definitions

a. Equipment Repair Time (ERT). Either the summation of all corrective maintenance task times after each task time has been multiplied by its individual task frequency, divided by the summation of the task frequencies; or a statistically developed approximation of the above which is satisfactory to the procuring activity.

b. Mmax. Time within which 90 percent of all corrective maintenance tasks can be accomplished.

c. Line Replaceable Unit (LRU). Any item whose flight line removal and replacement with a like serviceable item is considered the optimum corrective method for a specific higher indenture level item.

d. Shop Replaceable Unit (SRU). A subunit of an LRU which is normally removed and replaced to effect repair of the LRU.

e. Corrective Maintenance Task. The work performed as a result of a failure, for the purpose of restoring an item to a specific condition. The steps of a corrective maintenance task are: Fault isolation, Fault Correction, Adjustment/Calibration and Checkout. This includes the task of connecting and utilizing Support Equipment (SE) (if required) but excludes the tasks of positioning SE and obtaining spares resources.

f. Fault Correction. That step of a corrective maintenance task during which a failure is corrected by (1) repairing in place; (2) removing, repairing, and replacing a failed item; or (3) removing and replacing with a like serviceable item.

g. Fault Isolation. That step of a corrective maintenance task during which testing and analysis are performed on an item to locate a failure to the level of repair action.

h. Physical Adjustment/Calibration. That step of a corrective maintenance task during which manual adjustments or calibrations are made.

i. Checkout. That step of a corrective maintenance task during which performance of an item is verified to be restored to the full specification level.

j. Test Access Point. Any circuit access point which is specifically designed into the SRU for functional input/output, and/or test connection, shall be considered a test access point (Examples - all connectors and test jacks). In-circuit component tie points, eyelets, and solder pads are not considered test access points.

3.2.4.2 Repair

Organizational maintenance on the INU will be limited to the location, removal, and replacement of failed Line Replaceable Units (LRUs). Intermediate shop maintenance will be limited to the location, removal, and replacement of failed Shop Replaceable Units (SRUs).

a. The Equipment Repair Time (ERT) median at the Organizational Level is specified to be 18 minutes with an Mmax = 30 minutes (assuming free access to equipment as installed, i.e., the cockpit and any other necessary access door or panels are opened or removed) and includes the time to accomplish the following:

   (1) Location of a fault to an LRU.
   (2) Removal and replacement (not including vehicle access time).
   (3) Checkout of repair.

b. The Equipment Repair Time (ERT) median at the Intermediate Shop Level is specified to be 48 minutes with an Mmax = 1.5 hours and includes the items to accomplish the following:

   (1) Verification of a fault in an LRU.
   (2) Location of a fault to an SRU.
   (3) Removal and replacement of an SRU(s).
   (4) Calibration (when required) of the LRU.
   (5) Checkout of the repair.
   (6) Purge and fill.

3.2.4.2.1 Organizational-Level Maintainability Requirements

3.2.4.2.1.1 Equipment Handling

The equipment shall be designed and constructed such that "on-vehicle" maintenance can be performed in environments of humidity up to 100 percent relative, temperatures from -65 degrees F (minus 54 degrees C) to plus 160 degrees F (plus 71 degrees C) and specified sand and dust by personnel wearing clothing, such as heavy gloves, required by the particular environment. Required maintenance, such as testing, removal, replacement and hookup shall be possible over this expected range of flight line environments with only external cleaning or wiping allowed. The LRU shall be designed so that LRU handling or protective equipment is not needed for installation or for transport between the local maintenance and/or supply facility and the vehicle. The LRU mounting provisions for vehicle installation shall permit removal and replacement in five minutes or less by no more than one man using standard tools. Access and secure time shall not be included. The LRU weight limits shall be in accordance with the requirements of paragraph 5.9.11.3 of MIL-STD-1472.

3.2.4.2.1.2 Adjustments

Except for calibrations allowed in paragraph 3.2.4.1.1, "on-vehicle" adjustments, alignments or calibrations shall not be allowed for this equipment. If any adjustments, alignments or calibrations are required at the intermediate level of maintenance, except as specified in paragraph 3.2.4.1.1, these adjustments, alignments, or calibrations shall not be accessible at the Organizational Level of maintenance. The INU shall require no periodic maintenance.

3.2.4.2.1.3 Boresighting

Boresighting shall be in accordance with Appendix V.

3.2.4.2.1.4 INU Mount (Reference Only)

The INU mount shall provide for interchangeable installation of INUs without adjustment to retain INU boresight. In addition, boresight shall be retained through the environmental extremes specified in paragraph 3.2.5 and its subparagraphs.

3.2.4.2.1.5 INU Mount Bonding (Reference Only)

The footprint of the INU mount shall be conductive to provide a bonding resistance of less than 2.5 milliohms between the INU mount and the host platform structure ground.

3.2.4.2.2 Intermediate-Level Maintainability Requirements

3.2.4.2.2.1 Packaging

Elements within LRUs shall be packaged to group functionally related elements within common SRUs so as to minimize interconnections between SRUs and simplify fault isolation to a single SRU. All functional parts of the LRU shall be contained in separately removable, plug-in SRUs, except for the following:

a. Elapsed Time Meter
b. Connectors
c. Interconnecting Wiring
d. LRU Structure and Mounting Provisions
e. External Fault Indicators

3.2.4.2.2.2 Adjustments

SRUs shall be designed such that all replacement SRUs, when installed in an LRU, shall be immediately operable at design accuracy without requirements for continuity testing or functional adjustment or calibration of the replacement SRU or the LRU, except as approved in writing by the procuring activity. If such adjustments are approved, they should be distinctly labeled and accessible with the SRU installed in its normal position and without disturbing any other SRU or part.

3.2.4.2.2.3 Reversibility Restrictions

The equipment design and construction shall incorporate features such that it is mechanically and electrically impossible to install equipment incorrectly, and to attach cables, tubes, electrical plugs, and any other such items in an improper manner. Mechanically keyed mating, different size connectors, etc. shall be incorporated to eliminate all such possibilities. Shape of tubing tie-down provisions, color codes, labeling, etc. shall not be used as primary methods of satisfying this requirement.

3.2.4.2.2.4 Accessibility

a. The equipment shall be designed and constructed such that it shall be possible to remove and replace any SRU without removing or disconnecting any other assembly in the LRU unless otherwise approved in writing by the procuring activity. If removal of the LRU structure (i.e., covers) is required for access, such removal shall not affect electrical or mechanical alignment of the equipment nor shall the mechanical strength of the LRU be impaired to the point that damage to the equipment, its assemblies, subassemblies, or electrical harness will occur during normal bench handling of the LRU.

b. All SRU, assembly, and subassembly installation hardware and LRU covers which are required to be removed for SRU assembly or subassembly replacement shall employ captive-type hardware to prevent loss during normal field maintenance.

c. All LRU installation hardware shall be captive to prevent loss during vehicle maintenance.

d. The design and construction of the equipment shall provide ready access to test points and adjustments for the replacement of items in the shop.

3.2.4.3 Built-In-Test (BIT) Function

Suitable BIT features shall be incorporated into the INU to provide both a failure detection function and a failure location function. The BIT shall include the following:

a. Self-Tests. That portion of BIT which operates continuously and automatically in conjunction with the normal item operation. Self-test is usually the major technique for fault detection.

b. Operator-Initiated. Supplemental tests initiated by the system operator or maintenance technician. Appendix VII provides detailed requirements for the Operator Initiated Bit Mode.

c. The results of the above tests shall be available for display on the CDU and appear on the NAV status word and the Attitude Good Discrete. Verification of repair shall be accomplished by these tests. In addition, the INU shall provide an external indication, located near the elapsed time meter (visible on the INU as installed), that the LRU has failed self-test. The external indicator shall be resettable upon passing self-test.

If it cannot be clearly established that a malfunction is an internal INU fault, the INU will record the fault, alert the operator of an abnormal condition, but will not declare itself as failed.

3.2.4.3.1 Failure Detection Function

The failure detection function shall provide an indication of equipment status. The failure detection function shall energize an advisory or caution indicator when equipment performance is below an acceptable level both while on the ground and in flight. This indicator shall be on either the operator's panel (CDU) or at a remote location panel, or both, as th installation warrants. This Built-In-Test feature shall not require an auxiliary test devices external to the vehicle. The BIT circuitry shal automatically initiate a GO/NO-GO test upon equipment turn on and at periodic intervals unless it can be demonstrated that only on-demand, manually activated test modes are practical. Built-In-Tests shall minimize interface with the hardware functions.

3.2.4.3.1.1 Failure Detection Performance

The BIT capability to detect failures shall be that shown in Table III where (%FD) is percent failures detected and (%FFI) is percent false failure indications. In all cases (%FD) figures are minimum values whereas (%FFI) are not-to-exceed values.

Table III - BIT Requirements

PERCENT FAILURES DETECTED (%FD)	PERCENT FALSE FAILURE INDICATIONS (%FFI)
95 (Self-test only design goal - 99%)	1 (Self-test only)

$$(\%FD) = \frac{\text{\# of operational failures detected by BIT}}{\text{\# of total operational equipment failures}} \times 100$$

$$(\%FFI) = \frac{\text{\# of BIT failure indications not associated with an actual failure}}{\text{\# of operational failures detected by BIT}} \times 100$$

where: Failure is defined as any situation in which the unit does not meet specification requirements during operation, detected by any means.

3.2.4.3.2 Failure Location Function

The equipment shall incorporate features which shall locate a malfunction for the performance of Organizational and Intermediate Level maintenance.

3.2.4.3.2.1 Organizational Level

The failure location function shall locate a failure to a Line Replaceable Unit (LRU) both on the ground and in the air with no special test equipment. The built-in-failure location function shall obviate the need for any auxiliary test devices for maintenance at this level. The failure location function shall be implemented such that a signal device(s) located on the LRU clearly indicates when a malfunction has occurred within. The device shall be such that it will hold the last test result (GO/NO-GO) if power is interrupted or removed and be clearly visible to the maintenance technician when the equipment is installed in the vehicle. If it is determined that operator participation can enhance fault location, such manually conducted tests (limited to keyboard entry, test switch positioning, checklist lookup, display observation, etc.) shall be permitted. Regardless of operator participation, the 18 minute requirement of paragraph 3.2.4.2 applies.

3.2.4.3.2.2 Intermediate Level

The failure location function shall locate a failure to a Shop Replaceable Unit (SRU) within an LRU. The failure location function shall be implemented such that a signal device(s) located external or internal to the LRU clearly indicates where a malfunction has occurred. The device shall be such that it will hold the last test results (GO/NO-GO) if power is interrupted or removed and be clearly visible to the maintenance technician when the LRU is either installed in the vehicle, removed from the vehicle, or when an initial LRU maintenance action such as removal of an inspection plate, cover, etc. occurs. The INU shall incorporate external test connectors for the use of test equipment which will further enhance fault location to the SRU level. Each SRU shall contain sufficient test points in a test connector and normal interface connector to allow for the utilization of automated test equipment.

3.2.4.3.2.3 Failure Location Performance

The system capability to isolate faults shall be that defined in the following paragraphs:

a. Organizational Level. The percent malfunctions isolated to the correct LRU without ambiguity, out of the total number of malfunctions, shall not be less than 95% when located automatically, nor less than 98% when the automatic fault location function is enhanced by operator intervention (paragraph 3.2.4.2).

b. Intermediate Level. The faults shall be isolated to the correct SRU(s) without ambiguity.

(1) The minimum acceptable requirements, when no external test equipment is used, are as follows:

(a) In at least 85% of the cases, the fault shall be isolated to the correct SRU.

(b) In at least 90% of the cases, the fault shall be isolated to the correct SRU and no more than one other SRU.

(c) In at least 97% of the cases, the fault shall be isolated to the correct SRU and no more than two other SRU's.

(2) When external test equipment is used, the minimum acceptable requirements are as follows:

(a) In at least 97% of the cases, the fault shall be isolated to the correct SRU.

(b) In all cases, the fault shall be isolated to the correct SRU and no more than two other SRUs.

3.2.5 Environmental Conditions

The INU shall deliver specified performance under any and all probable combinations of environmental conditions contained in MIL-E-5400, paragraph 3.2.24 and its subparagraphs contained therein except as modified below.

3.2.5.1 Temperature

(Reference MIL-E-5400, paragraphs 1.2 and 3.2.24.1) The INU shall comply with Class 2X environmental requirements. The temperature of the air surrounding the INU (operational and non-operational conditions) may vary at a rate as high as 1.7 degrees Celsius per second within the applicable range. MIL-E-5400, Table I, Column I for Class 2 equipment is modified to read "-40 to +71 degrees Celsius" and Columns IX and X are modified to read "-54 to +95 degrees Celsius".

3.2.5.2 Altitude

(Reference MIL-E-5400, paragraph 3.2.24.2) The altitude (pressure) range is modified to include a steady state operation from 75,000 feet (0.5058 psia) down to minus 1,500 feet (15.1 psia), with intermittent operation from 75,000 feet (0.5058 psia) up to 80,000 feet (0.398 psia) for up to two minutes. The pressure may vary at a rate as high as 0.6 psia per second. Operation at surrounding pressures from 0.5058 to 0.398 psia shall be limited to two minutes per exposure.

3.2.5.3 Vibration

(Reference MIL-E-5400, paragraph 3.2.24.5) The INU shall provide normal performance as specified herein while subjected to the performance level of Figure 6 herein. Further, the INU shall survive, without damage or deterioration, a one hour per axis exposure to the endurance level of Figure 6 herein.

3.2.5.3.1 Gunfire Vibration

Gunfire vibration for all vehicle installations shall be satisfied by the random vibration endurance level of Figure 6.

3.2.5.4 Rain

The INU shall meet the performance requirements of this specification with water dripping from the overhead structure or in rain as may occur when the access panels are left open. The 45 degree drip-proof requirements of MIL-STD-108 and Requirement 31 of MIL-STD-454 are applicable.

3.2.5.5 Solar Radiation

INU equipment mounted in the cockpit shall meet the performance requirements of this specification when subjected to solar radiation of an intensity and for the duration specified in MIL-STD-810, Method 505.1, Procedure II.

3.2.5.6 Acoustic Noise

The INU shall meet the performance requirements of this specification and not suffer damage or deterioration when exposed to the acoustical environment specified in MIL-STD-810, Method 515.2, Procedure I, Category A.

3.2.5.7 Flight Environment

The INU shall meet performance requirements when subjected to the following flight environments (a, b, and c may occur in any combination):

PARAMETER	ACCELERATION	RATE	RANGE
a. Azimuth	± 6 rad/s/s	± 3 rad/s	Unlimited
b. Pitch	± 6 rad/s/s	± 1 rad/s	Unlimited
c. Roll	±17.5 rad/s/s	± 7 rad/s	Unlimited

d. Velocity ±3,000 fps in all axes
e. Latitude Unlimited in Navigate Mode
f. Altitude
-1,500 ft (-457.2 m) to +75,000 ft (22,860 m) steady-state
+75,000 ft (22,860 m) to +80,000 ft (24,384 m) intermittent (2 min)
g. Altitude Rate Up to 150,000 ft/min (45,720 m/min)
h. Linear Acceleration per paragraph 3.3.3.1.

3.2.5.8 Fluids

Fuel temperature will be within the range of -54 to +93 degrees Celsius. Hydraulic fluic lubricating oil, and coolant temperatures will be within the range of - to +135 degrees Celsius. Drain holes may be provided to prevent entrap. .t of fluids. The INU shall withstand contact with the following fluids without damage or degradation of performance:

a. Water
b. JP-4 and JP-5 Fuels (MIL-T-5624); JP-8 Fuel (MIL-T-83133)
c. Hydraulic Fluid (MIL-H-5606 and MIL-H-83282)
d. Lubricating Oil (MIL-L-7808)
e. Coolants of the Fluorocarbon, silicon, silicate ester, and glyco families
f. Anti-icing and Deicing - Defrosting Fluid (MIL-A-8243)

3.2.5.9 Shock

The INU shall survive, without damage or deterioration, the shock environments of handling, servicing, and transportation.

3.2.6 Transportability

The INU shall not require any special means of transportation. INU packing case(s) shall provide for safe, reliable, and efficient transport of units during shipment, by standard commercially available carriers.

3.3 Design and Construction

The INU shall be designed and constructed in accordance with MIL-E-5400 only to the extent covered in paragraph 3.2.5, herein, and its subparagraphs except as modified below.

3.3.1 Useful Life

The INU shall have a useful life of not less than 15 years under any combination of operating and storage life, when the operational service life has not been exceeded.

3.3.2 Operational Service Life

The INU shall have an operational service life of not less than 10,000 hours under any natural combination of environmental conditions specified herein. Operational service life is defined as the total operating time between the start of operation and wear out. Wear out is defined as the point where overhaul or repair cost exceeds one-half of the replacement cost of the equipment.

3.3.2.1 Storage

The INU shall meet all requirements of this specification without component or part replacement, adjustment, or maintenance after being in storage for up to 18 months.

3.3.3 Design Loads

The INU shall be designed to meet the following requirements. Load factors are referenced to aircraft coordinates.

3.3.3.1 Normal Operating Load Factors

The INU, when installed in the vehicle, shall meet all performance requirements of this specification during application of normal operating load factors between +12.0 g (down) and -6.0 g (up) and ± 6.1 g (side) acceleration and load factors of 7.5 g forward and aft. Reference is to the 3 axes of the vehicle in all vehicle attitudes. The INU shall not suffer damage, deterioration or permanent deformation while subjected to the normal operating load factors.

3.3.3.2 Ultimate Load Factors

The INU shall survive 1.5 times the normal operating load factors of 3.3.3.1 without failure (damage allowed) and without hazard during "power on" operation.

3.3.4 Thermal Design

The INU shall be designed to be forced air cooled with air supplied by the vehicle Environmental Control System (ECS) at the conditions and flows described in subparagraphs 3.3.4.1 and 3.3.4.2. The equipment shall require cooling air only when operating, but shall not be adversely affected by receiving cooling air when not operating. The INU shall use cold plates/heat exchangers so that none of the cooling air will come into contact with internal parts, circuitry or connectors. The INU shall incorporate a temperature sensing device for thermal protection. Automatic INU shut-off will occur when critical temperature limits are exceeded. BIT shall monitor the overtemp condition and shall be stored in the computer memory. The INU mount will be configured such that when the INU is removed from the vehicle, the air flow to the INU will be automatically shut-off at the mount.

3.3.4.1 Cooling Air Conditions

The INU shall be capable of satisfactory operation while being supplied 3.6 lb/min air at the minimum and maximum abnormal temperature limits for durations up to 30 minutes. The equipment shall sustain no permanent damage as a result of this exposure. The INU shall meet the performance requirements of this specification when exposed to the environmental conditions of paragraph 3.2.5 and when supplied with cooling air having the following characteristics:

a. Supply Air Temperature.

(1) Minimum for Preflight and ground maintenance:
-51 degrees Celsius.

(2) Minimum for vehicle ECS (flight and ground):
-18 degrees Celsius (normal) and
-54 degrees Celsius (abnormal).

(3) Maximum for Ground operation including startup:
+49 degrees Celsius.

(4) Maximum for inflight operation (all altitudes):
+38 degrees Celsius (normal) and
+49 degrees Celsius (abnormal).

(5) Variation: During normal operation, the supply air temperature may vary at a rate as high as 1.7 degrees Celsius per second within the above ranges. During start-up, the supply air temperature may vary at rates of as high as 5.5 degrees Celsius per second. The start-up variation on a cold day may occur over the range of -54 to +49 degrees Celsius. The start-up variation on a hot day may occur over the range of +49 to +100 degrees Celsius. The equipment shall sustain no damage as a result of exposure to start-up transients.

b. Water Content. Each pound of cooling air may contain up to 210 grains of water, including up to 55 grains in the form of free water.

c. Sand and Dust. Each pound of cooling air may contain up to 0.1 grams of dust, the particle size not exceeding 50 microns.

3.3.4.2 Cooling Air Flow

The INU shall deliver specified performance when exposed to the range of environmental conditions of paragraph 3.2.5 and supplied with cooling air between 3.6 lb/min and the minimum flow rate curve shown on Figure 3. All INU alignments shall be performed with cooling air supplied between the minimum and maximum flow rate curves of Figure 3.

3.3.4.3 Resistance to Overcooling

The INU shall meet the performance requirements when receiving cooling air as specified in 3.3.4.2 herein.

For interchangeability within the vehicle, the pressure loss of the delivered production units shall be as follows:

INU: 2 inches water, nominal, ± 10%. (All measurements shall be made at a flow rate of 1.2 lb/min, at an inlet temperature of +27 degrees Celsius, and at 14.7 psia).

3.3.4.4 Pressurization

No equipment pressurization air will be supplied from the vehicle environmental control system.

3.3.4.5 Cooling Air Connectors

Equipment mounted in supplier furnished mounts: The air inlet port for each INU shall be located so as to be compatible with a suitably located blind mating air plenum on the INU mount. A separate, automatically actuated, shut-off device shall be provided on the mount to prevent the direct flow of cooling air from the mount blind mating plenum when the INU is removed from the mount. Flow restriction devices shall not be used in supplier furnished mounts. The shut-off device shall be an integral part of the mount. A single air inlet connector per MS-33660 shall be provided on the equipment mount for connection to the vehicle source of cooling air. The size, orientation and location of this connector shall be subject to approval by the procuring activity. Suitable provisions shall be incorporated in the equipment mount to route cooling air from this connector to the INU air inlet port(s).

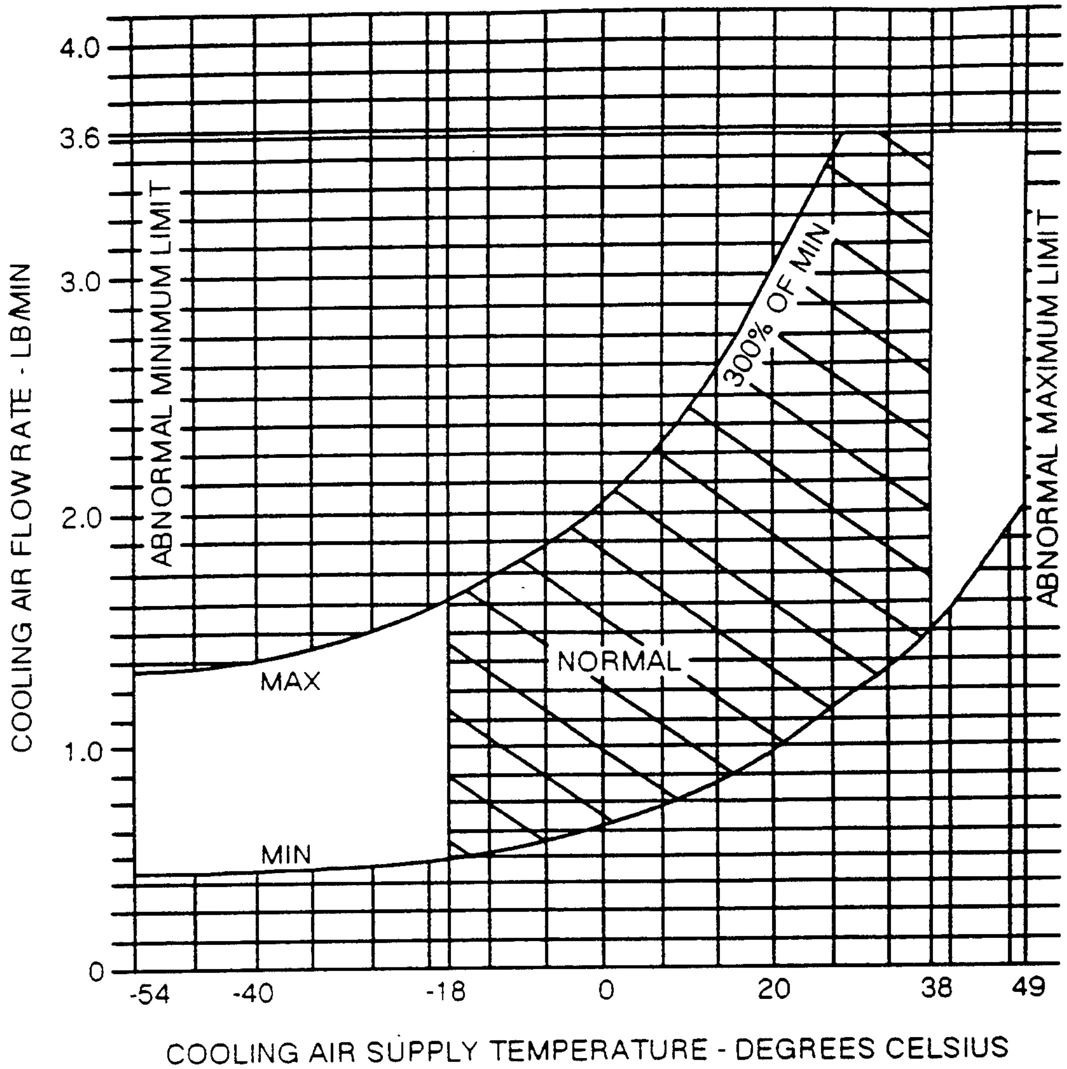


Figure 3
Cooling Air Flow

3.3.5 Electromagnetic Interference (EMI)

The INU system shall be designed using design handbook AFSC DH 1-4 as a guide. The generation of and susceptibility to electromagnetic interference shall be controlled in the INU. The INU shall meet the design requirements of MIL-STD-461 as specified and/or modified below. The specific requirements and modifications of MIL-STD-461 are as follows:

TEST METHOD

CE01 - This test shall be performed for data purposes only.

CE03 - Change frequency range to "0.10 MHz to 50 MHz". Data shall be collected from 0.014 MHz to 0.10 MHz for information purposes.

RS02 - The procedures and limits of Method RS02 (a) and (b) shall apply except that voltage E of Part (b) shall be 400 volts across 5 ohms.

CS01, CS02, CS06, RE02, RS03, CE04 - Per MIL-STD-461.

In addition, the following EMC requirements shall apply:

a. Transient (Impulse) Susceptibility. No change in indications, malfunction, or degradation of performance shall be indicated in the INU or its loads when exposed to an electromagnetic impulse field generated by a type MS25271 relay or an acceptable equivalent when wired for continuous operation with a switch in series with the positive side of the line from a 28 volt DC power source. No suppression components (shielding, diodes, etc) shall be attached to the relay or its wiring. The unshielded positive lead leaving the switch shall be laid over three sides of the test sample and then connected to the relay. The unshielded return lead from the relay shall be taped to and in parallel with input power leads, signal leads, and interconnecting leads. The total length of each external wiring harness paralleled with the relay circuit shall not be less than 60 inches. The 28 volts input shall be reversed and the transient repeated.

b. Magnetic Susceptibility. The INU shall operate without degradation of performance when subjected to a magnetic field which has a magnitude of 4 gauss at the equipment envelope and a gradient of 20 gauss per foot, or a field which has a gradient of 2.5 gauss per foot and a calculated level of 1 gauss at the center of the sensitive item within the INU equipment.

3.3.5.1 Bonding

The INU equipment shall be designed to provide a continuous low impedance path from the equipment enclosure to its intended mounting rack. In accordance with paragraph 3.3.5.1 of MIL-B-5087, the direct current resistance of this path shall be less than 2.5 milliohms. Use of bonding straps, jumpers, or bonding clamps between the equipment enclosure and the mounting rack shall not be allowed.

3.3.6 Nameplates and Product Marking

All parts and assemblies shall be marked in accordance with MIL-E-5400, paragraph 3.1.16. A nameplate conforming to the requirements of MIL-STD-130 shall be permanently attached to each unit.

3.3.7 Workmanship

Workmanship shall be in accordance with MIL-STD-454, Requirement 9.

3.3.8 Safety

The system safety criteria and requirements of MIL-STD-454, Requirements 1 and 3, AFSC DH 1-6 and paragraphs 5.4 and 5.6 of MIL-STD-882 are applicable.

3.3.8.1 Safety Markings

Warnings/cautions and other markings shall be applied as necessary to aid personnel in avoiding potential hazards. Unless otherwise specified, such markings shall be consistent with MIL-STD-1472 except that warnings shall be white on conspicuous red, and cautions black on bright yellow with a black border.

3.3.9 Human Engineering

The design of the INU including design specification manuals, and calibration procedures supporting this equipment shall be in accordance with MIL-STD-1472 requirements.

3.3.10 Elapsed Time Meter

The INU shall include a 9999 hour, digital, non-resettable, elapsed time meter conforming to MS17322 and MIL-M-7793. The meter shall be located on the front of the INU and shall be easily readable without removing the INU cover when mounted in the vehicle.

3.3.11 Connectors

Connectors shall conform to Requirement 10 of MIL-STD-454. Support Equipment (SE) connectors shall conform to MS-27505. Power and signal connectors shall conform to MIL-C-83733.

3.3.12 Parts, Materials and Processes

The parts, materials, and processes shall be in accordance with paragraph 3.1 of MIL-E-5400 and shall be subject to the approval of the procuring activity prior to their use.

3.3.12.1 Microcircuits

Microcircuits shall conform to Requirement 64 of MIL-STD-454, Class B devices. Non-standard microcircuits shall be screened to Method 5004.2, MIL-STD-883, Class B requirement as a minimum. Plastic encapsulated microcircuits shall not be used.

3.3.12.2 Semiconductors

Semiconductors shall conform to Requirement 30 of MIL-STD-454, JANTX CLASS. Non-standard semiconductors shall be screened to equivalent JANTX requirements. Plastic encapsulated semiconductors shall not be used.

3.3.12.3 Passive Devices

Passive devices shall be selected from the Established Reliability (ER) specifications of MIL-STD-454.

3.3.12.4 Non-Standard Parts

Non-standard parts require procuring activity approval prior to use. Non-standard parts shall be equal to or better than the same type military standard part and where possible shall be replaceable in the field by a military standard part. Parts used in tests must be used in subsequent production, spares, etc.

3.3.13 Finishes and Colors

Equipment installed in the cockpit area shall be Lusterless Black, Color No. 37038 in accordance with FED-STD-595. Finish of all other equipment shall be Lusterless Gray Color No. 36231, in accordance with FED-STD-595.

3.3.14 Handles and Grasp Areas

Each unit shall be designed for ease of handling during installation and maintenance. Handles shall not be required. Grasp areas shall be in accordance with paragraph 5.9.11.5 of MIL-STD-1472.

3.3.15 Environmental Protection

Using personnel shall be protected from any adverse environmental conditions (e.g., temperature, shock, vibration and low pressure) in which the INU may be employed per paragraph 5.13 of MIL-STD-1472.

3.3.15.1 Toxicity

Personnel exposure to toxic air contaminants during INU operation, maintenance and training shall not exceed the ceiling values of OSHA Standard 1910.93.

3.3.15.2 High Voltage

Personnel exposure to high voltage during INU operation, maintenance and training shall be in accordance with Requirement 1 of MIL-STD-454.

3.3.16 Hazard Protection

Hazards which may cause adverse explosive, fire, mechanical, or biological effects on personnel during INU operation, test, maintenance and training shall be eliminated or controlled.

3.3.17 Switching Transients

Transients from switching within the equipment, whether automatically or manually controlled, shall be minimized by good equipment design.

3.3.18 Overload Protection

In addition to the overload protection requirements of 3.2.20 of MIL-E-5400, the INU shall be protected from chain reaction failures, including those from external overloads (shorts) caused by grounding of external wiring during installation, test, or other causes. In so far as practical, no damage to the INU shall result from open circuits or grounding of wiring external to the LRU.

3.3.19 Modular Design

The INU shall utilize modular space assignment and plug-in subassemblies to the greatest extent possible, consistent with requirements of this specification. Modules shall be designed on a functional block basis that permits simple functional checkout for location of malfunction and to facilitate repair. Modules which cooperate to achieve an identifiable subfunction shall be located together within a single unit of the equipment to the greatest possible extent. Potted or sealed modules which cause difficulty in basic part replacement shall be used only when required.

3.3.20 Personnel and Training

The design of the INU shall be such that its maintenance shall not require skills that exceed Level 5 as defined in AFM 39-1, Airman Classification Manual.

3.3.21 Protection of Electrostatically Sensitive Parts, Assemblies and Equipment

Where equipment design dictates the use of electrostatically sensitive parts, protection shall be in accordance with provisions of DOD-STD-1686.

3.3.22 INU Resonance

There shall be no INU resonance below 20 Hz and there shall be no resonance Q level greater than 4 between 20 Hz and 30 Hz.

3.3.23 INU Computer Processing Design Requirements

a. Programming Language. Air Force approved Higher Order Language (HOL) as described in MIL-STD-1589 (JOVIAL J73) is used for all real-time processing within the INU. If there is significant rationale for using other than MIL-STD-1589, it shall be fully stated in a request for deviation to the procuring activity. A trade-off analysis shall be provided which fully justifies, in a quantitative way, the rationale for selection of a different Air Force approved HOL or any other non-approved language. The rationale provided must include life cycle cost, supportability, technical risk, and schedule risk. A mixture of HOL and assembly language is acceptable, but at least 90% of the executable code shall be generated from HOL source code. Deviation from use of an approved Air Force HOL will require submission of a request and sufficient justification to support a waiver.

b. Instruction Set. MIL-STD-1750 Sixteen Bit Computer Instruction Set Architecture is the required instruction set for the INU. If a non-MIL-STD-1750 instruction set is chosen, a trade-off analysis must be provided which fully justifies to the procurring activity, in a quantitative way, the rationale for the instruction set chosen. The areas for which rationale is to be provided must include life cycle cost, supportability, technical risk, and schedule risk. Deviation from use of MIL-STD-1750 shall require submission of a request and sufficient justification to support a waiver.

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4. QUALITY ASSURANCE PROVISIONS

4.1 General

The INU shall be subjected to verification in accordance with the requirements of this section to demonstrate compliance with this specification. The provisions of MIL-STD-810 as specified herein and the requirements of this section shall apply. When the two documents are in conflict, this specification shall govern. A record shall be made of all data necessary to determine compliance with performance requirements. A cross reference of requirements to verification method is provided in Table IV. Compliance with the requirements of Section 3.0 shall be verified by inspection, analysis, demonstration, test, or a combination thereof as defined below:

a. Inspection. Inspection is defined as a visual verification that the equipment as manufactured conforms to the documentation to which it was designed.

b. Analysis. Analysis is defined as the verification that a specified requirement has been met through the technical evaluation of equations, charts, reduced data and/or representative data.

c. Demonstration. Demonstration is defined as a non-instrumented test where success is determined by observation alone. Included in this category are tests that require simple quantitative measurements such as dimensions, time to perform tasks, etc.

d. Test. Test is defined as the verification that a specified requirement is met by a thorough exercising of the applicable element under appropriate conditions in accordance with test procedures.

4.1.1 Responsibility for Tests

All inspections, analyses, demonstrations and tests will be performed at the facilities specified in the contract statement of work.

4.1.2 Test Samples

The quantity and schedule for delivery of all test samples submitted for inspection and/or test will be specified in the contract statement of work.

4.1.3 Standard Conditions

The following conditions shall be used to establish normal functional performance characteristics:

a.	Ambient Room Temperature	23 ± 10 degrees Celsius
b.	Surrounding Air Pressure	Prevailing lab conditions
c.	Relative Humidity	Room ambient up to 90%
d.	Input Power	AC: 115 +3 Volts, -7 Volts, 400 ±20 Hz, 26 +2 Volts, -6 Volts, 400 HZ, in phase with aircraft Primary Power DC: 28 +0.5 Volts, -4.0 Volts
e.	Cooling Air Temperature	Per Figure 3
	Cooling Air Humidity	Up to 95% relative
	Cooling Air Flow	Per Figure 3, Cooling Air Flow

4.1.4 Test Apparatus Accuracy

All test equipment shall comply with the requirements of MIL-STD-810, paragraph 3.1.3.

4.1.5 Failure Criteria

A failure is defined to be a complete malfunction or a reduction in the performance of the INU below the requirements of this specification which was corrected by repair, replacement, or calibration of any part of the INU. A failure must be disregarded if it can be convincingly proven that it was caused by abnormal external events or human errors in operating and handling equipment. Failures can be catastrophic or structural in nature. The following criteria shall constitute a failure:

a. The failure symptoms must be repeatable.

b. For systems which have mechanized the selectable "CAL" mode, unscheduled calibrations, unscheduled maintenance and/or unscheduled reprogramming are failures if they occur within 60 days of the previous calibration. For systems which have not mechanized the "CAL" mode, unscheduled calibrations, unscheduled maintenance and/or unscheduled reprogramming are failures if they occur within 18 months.

c. Monitored functional parameters that deviate beyond acceptable specification limits shall constitute a failure.

d. Deterioration, corrosion, or change in tolerance limits of any internal or external parts which prevent the test item from meeting operational service or maintenance requirements constitute failures.

Table IV - Quality Assurance Cross Reference

REFERENCE	REQUIREMENT	LABORATORY
3.1	Item Description	4.2.1
3.1.1	Item Diagram	4.2.1
3.1.2	Interface Definition	4.2.3.2
3.1.2.1	Bus Control	4.2.3.2
3.1.2.1.1	Data Bus Redundancy	4.2.3.2
3.1.2.1.2	Bus Address	4.2.3.2
3.1.2.1.3	Status Word BIT Assignment	4.2.3.2
3.1.2.1.4	Mode Commands	4.2.3.2
3.1.2.1.5	Input/Output (I/O)	4.2.3.2
3.2	Characteristics	-
3.2.1	Performance	4.2.3.2
3.2.1.1	Position Accuracy	4.2.3.2
3.2.1.2	Velocity Accuracy	4.2.3.2
3.2.1.3	Acceleration Accuracy	4.2.3.2
3.2.1.4	Attitude Accuracy	4.2.3.2
3.2.1.5	Altitude Accuracy	4.2.3.2
3.2.1.6	Reaction Times	4.2.3.2
3.2.1.7	Latitude Range	-
3.2.1.8	Vehicle Motion During Gyrocompass Alignment	-
3.2.1.9	INU Functions	4.2.3.2
3.2.1.10	Selectable Modes	4.2.3.2
3.2.1.11	Data Output	4.2.3.4
3.2.1.12	Validity Output Discretes	4.2.3.2
3.2.1.13	Data Latency	4.2.3.2
3.2.2	Physical Characteristics	-
3.2.2.1	Size	4.2.3.1
3.2.2.2	Electrical Interface	4.2.3
3.2.2.3	Electrical Power	4.2.4.4
3.2.3	Reliability	-
3.2.3.1	Reliability of Replacement and Spare SRU/Modules	4.2.8
3.2.4	Maintainability Program	4.2.7
3.2.4.1	Design	4.2.7
3.2.4.1.1	Calibration Interval	4.2.3
3.2.4.1.2	Maintainability Definitions	-
3.2.4.2	Repair	4.2.7
3.2.4.2.1	Organizational Level Maintainability Requirements	4.2.7
3.2.4.2.1.1	Equipment Handling	4.2.7
3.2.4.2.1.2	Adjustments	4.2.7
3.2.4.2.1.3	Boresighting	4.2.7
3.2.4.2.1.4	INU Mount	4.2.7
3.2.4.2.1.5	INU Mount Bonding	4.2.7

Table IV - Quality Assurance Cross Reference (continued)

REFERENCE	REQUIREMENT	LABORATORY
3.2.4.2.2	Intermediate Level Maintainability Requirements	4.2.7
3.2.4.2.2.1	Packaging	4.2.7
3.2.4.2.2.2	Adjustments	4.2.7
3.2.4.2.2.3	Reversibility Restrictions	4.2.7
3.2.4.2.2.4	Accessibility	4.2.7
3.2.4.3	Built-In-Test (BIT) Function	4.2.7
3.2.4.3.1	Failure Detection Function	4.2.7
3.2.4.3.1.1	Failure Detection Performance	4.2.7
3.2.4.3.2	Failure Location Function	4.2.7
3.2.4.3.2.1	Organizational Level	4.2.7
3.2.4.3.2.2	Intermediate Level	4.2.7
3.2.4.3.2.3	Failure Location Performance	4.2.7
3.2.5	Environmental Conditions	4.2.4.2
3.2.5.1	*Temperature	4.2.4.2.1
3.2.5.2	*Altitude	4.2.4.2.1
3.2.5.3	*Vibration	4.2.4.2.3
3.2.5.3.1	Gunfire Vibration	4.2.4.2.15
3.2.5.4	Rain	4.2.4.2.5
3.2.5.5	Solar Radiation	4.2.4.2.9
3.2.5.6	Acoustic Noise	4.2.4.2.13
3.2.5.7	Flight Environment	4.2.3.2
3.2.5.8	Fluids	4.2.4
3.2.5.9	*Shock	4.2.4.2.14
3.2.6	Transportability	4.2.1 & 4.2.7
3.3	Design and Construction	4.2.1
3.3.1	Useful Life	4.2.1 & 4.2.7
3.3.2	Operational Service Life	4.2.1 & 4.2.7
3.3.2.1	Storage	4.2.1 & 4.2.7
3.3.3	Design Loads	-
3.3.3.1	Normal Operating Load Factors	-
3.3.3.2	*Ultimate Load Factors	4.2.4.2.14
3.3.4	Thermal Design	4.2.4.2.4
3.3.4.1	Cooling Air Conditions	4.2.4.2.4
3.3.4.2	Cooling Air Flow	4.2.4.2.4
3.3.4.3	Resistance to Overcooling	4.2.4.2.4
3.3.4.4	Pressurization	4.2.4.2.4
3.3.4.5	Cooling Air Connectors	4.2.3.1
3.3.5	Electromagnetic Interference (EMI)	4.2.4.3
3.3.5.1	Bonding	4.2.4.3
3.3.6	Nameplates and Product Marking	4.2.1
3.3.7	Workmanship	4.2.1
3.3.8	Safety	4.2.2
3.3.8.1	Safety Markings	4.2.1

Note: The '*' indicates a Safety of Flight (SOF) item. See paragraph 4.2.4.2.

Table IV - Quality Assurance Cross Reference (continued)

REFERENCE	REQUIREMENT	LABORATORY
3.3.9	Human Engineering	4.2.1
3.3.10	Elapsed Time Meter	4.2.1
3.3.11	Connectors	4.2.3.1
3.3.12	Parts, Materials & Processes	4.2.1
3.3.12.1	Microcircuits	4.2.1
3.3.12.2	Semiconductors	4.2.1
3.3.12.3	Passive Devices	4.2.1
3.3.12.4	Non-Standard Parts	4.2.1
3.3.13	Finishes and Colors	4.2.1
3.3.14	Handles and Grasp Areas	4.2.1
3.3.15	Environmental Protection	4.2.1
3.3.15.1	Toxicity	4.2.1
3.3.15.2	High Voltage	4.2.1 & 4.2.4.4
3.3.16	Hazard Protection	4.2.1
3.3.17	Switching Transients	4.2.1 & 4.2.4.4
3.3.18	Overload Protection	4.2.4.4
3.3.19	Modular Design	4.2.3.1
3.3.20	Personnel Training	4.2.1
3.3.21	Electrostatic Protection	-
3.3.22	INU Resonance	-
3.3.23	INU Computer Processing Design Requirements	4.2.1

4.1.6 Test Sample Refurbishment

The test samples which have been subjected to testing and exhibit deterioration shall not be delivered on contract until they have been refurbished. The wear items to be replaced shall be determined by agreement between the contractor and the procuring activity. Test samples which have been subjected to safety of flight crash loads shall not be delivered on contract.

4.1.7 Functional Tests

Functional tests are required during acceptance, product verification, and pre/post-qualification tests. The following criteria shall apply to the attitude and navigation accuracy parts of these tests:

a. Attitude Test. The attitude test shall start with the INU stabilized at room temperature with all power off. The INU will be turned on and allowed to complete a full alignment before entering the navigation mode. Following the alignment sequence, the INU case will be incrementally positioned in azimuth, pitch, roll and compound pitch and roll. The INU output data will be allowed no more than 5 seconds stabilization time before a comparison of case position to output data position in all three axes is recorded. A failure is defined as any difference in azimuth, pitch, or roll by more than 0.125 degree between case orientation and output data orientation.

b. Navigation Test. The navigation test shall consist of two in place navigation runs at two different headings. Each navigation run shall start with the INU stabilized at room temperature with all power off. The INU will be turned on and allowed to complete a full alignment before entering the navigation mode. Radial position error shall not exceed 0.5 nmi during the first 15 minutes of navigation and shall not exceed 2.0 nmi/hr during the remainder of the test. The velocity error in either horizontal axis shall not exceed the following limits: 0.25 fps at the instant the navigation mode is entered, 8.0 fps peak to peak oscillation, and 2.5 fps RMS for the first two hours of the test based on velocity data recorded at five minute intervals.

   (1) The first run of the navigation tests shall consist of a stationary run of at least 90 minutes after entry into the navigation mode. The test will be performed at a case heading of North.

   (2) The second navigation run shall consist of a stationary run of at least 90 minutes after alignment. This run shall be accomplished at an East case axis heading.

4.1.8 Performance Checks

The procedures, test parameters, etc required to accomplish performance checks shall be submitted to the procuring activity for review and approval prior to commencing any tests.

4.2 Test Classification

Inspection and testing of the INU will be classified as follows:

a. Examination of Product - paragraph 4.2.1
b. Operational Flight Program Demonstration - paragraph 4.2.2
c. Acceptance Test - paragraph 4.2.3
d. Qualification Test - paragraph 4.2.4
e. Combined Environments Test - paragraph 4.2.5
f. Production Verification Test - paragraph 4.2.6
g. Maintainability Demonstration - paragraph 4.2.7

4.2.1 Examination of Product

Each test item submitted shall be given a thorough visual and mechanical inspection to determine that the quality of material, workmanship and design is in compliance with the requirements of this specification.

4.2.2 Operational Flight Program (OFP) Demonstration

The procedures required to demonstrate that the OFP, when resident in the INU hardware, complies with the functional and performance requirements of this specification shall be submitted to the procuring activity for review and approval prior to commencing the formal OFP demonstration. Realism in simulating operational conditions shall be a prime consideration in structuring demonstration procedures. The OFP shall be verified as in compliance with the functional and performance requirements of this specification when formal OFP demonstration has been completed with no out of specification conditions detected.

4.2.3 Acceptance Test

Each deliverable item shall be subjected to the following acceptance tests.

4.2.3.1 Examination of Product

Each deliverable item shall be examined to determine conformance with the applicable drawing and all requirements of this specification for which there is not a specific test. In addition, the requirements of paragraph 4.2.1 of this specification shall apply.

4.2.3.2 Functional Tests

The functional characteristics of the equipment shall be measured in accordance with the acceptance test procedures and the data recorded. Any equipment found out of tolerance shall be rejected. The acceptance test procedures shall be submitted to and approved by the procuring activity prior to use in formal testing.

a. Data Response Time and parameter bandwidth shall be verified by analysis. This analysis shall ensure that the full range of performance of this specification is covered.

4.2.3.2 (continued)

b. The data jitter requirements of Table I shall be verified by a static test on an early/current OFP in a production INU. After this initial test, a static jitter test shall be performed on each production OFP release to verify the requirements of Table I; or the jitter requirements of Table I may be verified by analysis. If the analysis indicates that the jitter requirements of Table I are not being met, a static test shall be performed to verify this result. In any case a static jitter test shall be performed on an early/current OFP in a production INU. Reference jitter definition in para 6.7.4.

4.2.3.3 Rejection and Retest

Equipment which has failed to meet the acceptance tests of this specification shall be rejected. Final acceptance of rejected equipment shall not be made until it is determined that the item meets all acceptance test requirements. The equipment may be reworked or have parts replaced to correct the cause of rejection. Full particulars concerning the rejection and action to correct the fault shall be submitted with the equipment.

4.2.3.4 Test Conditions

Unless otherwise specified, all acceptance tests shall be conducted under the standard conditions of paragraph 4.1.3.

4.2.4 Qualification Tests

This test series shall be used to certify that the INU complies with the requirements of this specification. The location(s) where testing will be conducted and the required surveillance of tests shall be as stated in the contract.

a. Test Samples. The test samples shall consist of models representative of production equipment. The quantity to be subjected to qualification testing shall be specified in the contract.

b. Certification. Certification of the satisfactory completion of qualification tests shall be submitted to the government as required by the contract.

c. Test Sequence. The following sequence of tests shall be used to accomplish the qualification test series:

(1) Prequalification Acceptance Test, see paragraph 4.2.4.1
(2) Environmental Tests, see paragraph 4.2.4.2
(3) Electromagnetic Interference Tests, see para. 4.2.4.3
(4) Electrical Power Test, see paragraph 4.2.4.4
(5) Post-Qualification Functional Test, see para. 4.2.4.5

4.2.4.1 Prequalification Acceptance Test

A complete acceptance test in accordance with paragraph 4.2.3 shall be performed on each test item prior to the start of the environmental, EMI, and other tests in this series.

4.2.4.2 Environmental Tests

Environmental tests shall be in accordance with MIL-STD-810 except as modified herein. The equipment shall be subjected to performance checks (paragraph 4.1.8) before, during (unless otherwise specified), and after each environmental test to determine satisfactory operation. The equipment under test shall sustain neither physical damage nor performance degradation either during or as a result of exposure to these tests. If Combined Environments Testing (CET) is performed as specified in paragraph 4.2.5 of this specification, then paragraph 4.2.4.2.1 through paragraph 4.2.4.2.3 may be optional if contractually specified. Otherwise, the following testing shall be accomplished. Tests indicated with an asterisk shall be performed on the equipment prior to the first flight in any vehicle (Safety of Flight). Safety of Flight (SOF) tests required are as described in paragraphs 4.2.4.2.1, 4.2.4.2.3, 4.2.4.2.10, 4.2.4.2.12, and 4.2.4.2.14.

4.2.4.2.1* Temperature and Altitude (SOF)

Test in accordance with MIL-STD-810, Method 504.1, Procedure I (Category 6) for the temperature and altitude requirements of paragraph 3.2.5.1 and 3.2.5.2 herein.

4.2.4.2.2 Humidity Test

Test in accordance with MIL-STD-810, Method 507.1, Procedure I.

4.2.4.2.3* Random Vibration (SOF)

Test in accordance with MIL-STD-810, Method 514.2 for the performance and endurance levels as specified in Figure 6 herein. The INU shall be subjected to one half-hour of performance test, followed by one hour of endurance test, completed by one half-hour of performance test in each of its three orthogonal axes. During the performance test the INU shall demonstrate requirements of paragraph 3.2.1. However, during the endurance test, the INU shall be in the NAV mode, and system performance shall be checked by functional testing upon completion of the test. While the functional tests are being performed, the INU shall be mounted with respect to its vehicle installed axes and shall not be subjected to vibration. SOF tests shall consist of a fifteen minute performance test in each axis.

4.2.4.2.4 Cooling Air

The purpose of these tests is tc ›nsure the INU meets the performance re-uirements when designed to b€ 'orced air cooled and supplied with cc ing air over the specified des: . range.

a. Air Flow and Pressure Loss. The system will be operated in the maximum heat dissipating mode. The cooling air temperature and flow rate shall be adjusted to the specified conditions. The total air pressure loss through the INU shall be compared to the specified maximum allowable loss.

b. Overcooling. The INU shall be stabilized at -40 ± 2 degrees Celsius at ambient pressure. The cooling air shall be adjusted to -18 degrees Celsius at three times the minimum specified flow rate. The INU shall be turned on, aligned and operated in the NAV mode for 84 minutes. No degradation of performance shall be allowed. The test shall be repeated with operation in the NAV mode for 30 minutes, bu with cooling air temperature of -51 degrees Celsius, for whic degraded performance is allowed.

c. Und :cooling. The INU ill be stabilized at +71 ± 2 degrees Celsius at ambient pressu . The cooling air shall be adjusted to +38 degrees Celsius at the minimum specified flow rate. The INU shall be turned on, aligned and operated in the NAV mode for 84 minutes. No degradation of performance shall be allowed. The test shall be repeated with operation in the NAV mode for 30 minutes, but with cooling air at +49 degrees Celsius, for which degraded performance is allowed.

4.2.4.2.5 Rain

Test in accordance with MIL-STD-810, Method 506.1, Procedure II.

4.2.4.2.6 Sand and Dust

Test in accordance with MIL-STD-810, Method 510.1, Procedure I.

4.2.4.2.7 Fungus

Vendor certification shall be accepted for well established materials. However, the government reserves the right to test the INU in accordance with fungus test Method 508.1 of MIL-STD-810, Procedure I.

4.2.4.2.8 Salt Fog

Test in accordance with MIL-STD-810, Method 509.1, Procedure I.

4.2.4.2.9 Solar Radiation

Test in accordance with MIL-STD-810, Method 505.1, Procedure II (for INUs mounted in the cockpit only).

4.2.4.2.10* Explosive Atmosphere (SOF)

Explosion proof testing on all INU equipment which is not hermetically sealed or which is not enclosed in pressurized or sealed containers shall be conducted to accordance with MIL-STD-810, Method 511.1, Procedure I, modified to include 75,000 feet simulated altitude in paragraph 3.1.2 of Procedure I.

4.2.4.2.11 Linear Acceleration - Limit Load

The purpose of this test is to verify satisfactory performance after the application of limit loads.

a. The test shall be performed with an INU mounted on a centrifuge.

b. The INU shall be prepared in accordance with appropriate pre-test performance requirements, gyrocompass aligned, and placed in the NAV mode for ten minutes of static navigation.

c. The INU shall be maintained in the NAV mode during acceleration and for 84 minutes after each acceleration. Record INU horizontal position and velocity once per minute for each test.

d. With the case oriented so that lateral loading is placed on the case by the centrifuge when it rotates, impose a steadily increasing acceleration on the INU peaking at 2 g's. Total test time is limited to five minutes and the angular rate shall not exceed 3 radians per second during test. Rotate the case 180 degrees about a vertical axis, then impose a steadily increasing acceleration on the INU peaking at 2 g's. Time and angular rate limitations are as above.

e. Orient the case to simulate a vehicle in vertical flight that is experiencing negative g's. Impose a steadily increasing g-load on the case peaking at 6 g's. Total time is limited to 7 minutes and the angular rate shall not exceed 7 radians per second.

f. Orient the case as shown in Figure 4 to simulate a vehicle experiencing a 13 g normal acceleration with a simultaneous 4 g deceleration (forward load). Impose a steadily increasing centrifugal load peaking at 13.56 g's so that down and forward loads are 13 g's and 4 g's respectively. Total test time is limited to 10 minutes and the centrifuge angular rate shall not exceed 7.51 rad/s (equivalent to 7 rad/s about the roll axis and 2.73 rad/s about the yaw axis). Rotate the case 180 degrees with respect to the case vertical axis, then impose a steadily increasing centrifugal load peaking at 13.56 g's. Time and angular limitations are as above.

g. A time history of horizontal position and velocity errors indicated by the INU during each test shall be plotted. These results shall be compared with the specified position and velocity accuracy requirements.

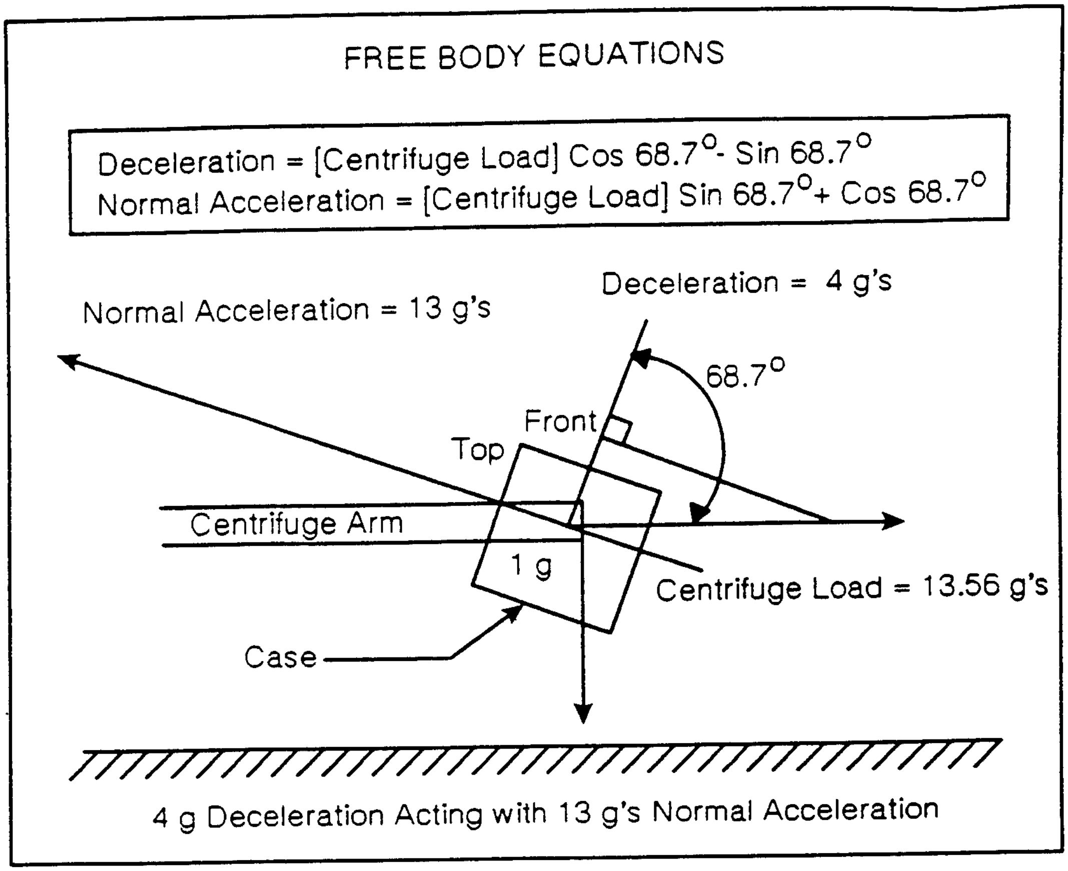


Figure 4
Linear Acceleration Test Set-Up

4.2.4.2.12* Sinusoidal Vibration (SOF)

Test in accordance with MIL-STD-810, Method 514.2, Procedure I, Figure 514.2-3 Level M.

4.2.4.2.13 Acoustic Noise

Test in accordance with MIL-STD-810, Method 515.2, Procedure I, Category A.

4.2.4.2.14* Shock (SOF)

Test in accordance with MIL-STD-810, Method 516.2, Procedures I, II, III, and V.

4.2.4.2.15 Gunfire Vibration

Testing of this requirement will have been accomplished previously under paragraph 4.2.4.2.3 test guidelines.

4.2.4.2.16 Toxicity

Materials in the equipment which appear in Tables G-1, G-2, and G-3 of OSHA Standard 1910.93 will be identified. Designs containing such materials are limited to the ceiling values on eight-hour time weighted averages given in the above tables. Tests will be conducted to determine material concentrations whenever analyses are inconclusive.

4.2.4.3 Electromagnetic Interface (EMI) Tests

Compliance with the applicable requirements of MIL-STD-461 specified in paragraph 3.3.5 shall be demonstrated by testing of the INU in accordance with MIL-STD-462, test methods CE01, CE03, CE04, CS01, CS02, CS06, RE02, RS02 and RS03. Compliance with Transient (Impulse) Susceptibility, Magnetic Susceptibility, and bonding requirements of paragraph 3.3.5 shall be demonstrated by testing the INU in accordance with plans/procedures approved by the procuring activity.

4.2.4.3.1 Test Cable Shield Terminations

For purposes of EMI testing, the shields on wiring of the test set signal connector (simulating vehicle cabling to the INU) shall be bonded to the INU mount by means of a ground strap with a length-to-width ratio of less than five to one, and a direct current resistance of less than 2.5 milliohms.

4.2.4.3.2 Test 28 VDC Grounding

For purposes of EMI testing, the battery 28 VDC return power lines (P-132 pins 40, 50 and 51) shall be bonded to the test ground plane.

4.2.4.4 Electrical Power Test

The system shall be prepared in accordance with the performance of test requirements (MIL-STD-810, paragraph 3.2). Outputs of velocity and attitude will be recorded during power tests.

a. Normal and Emergency AC Power. The INU shall be operated in the NAV mode at the voltages of 104, 113, 108, 113, 118, 113, and 122 for a period of not less than 10 minutes for each voltage value.

b. AC Power Factor. The INU individual phase power factors shall be determined with the system operating in the NAV mode and shall meet the limits of Table II of this specification.

c. AC Frequency. The INU shall be operated in the NAV mode at 400 Hz, 420 Hz, 380 Hz and 400 Hz for a period of not less than 10 minutes for each frequency.

d. AC Transients. The INU shall be tested for AC transient sensitivity as specified in MIL-STD-704, limits 1 and 4 of Figure 3. The INU shall be operated in the NAV mode for a period of not less than 10 minutes following each transient.

4.2.4.4.1 Aircraft 28 Volts DC Discrete Power

a. Normal and Emergency Levels. The INU shall be operated in the NAV mode at the normal aircraft power distribution 28 volt DC line voltages of 16, 28, 24, 28, 22.5, 28, 30 and 28 VDC for a period of not less than 10 minutes for each voltage value.

b. DC Transients. The INU shall be tested for DC transient sensitivity by applying transient voltages on the normal aircraft power distribution 28 VDC line, as specified in MIL-STD-704, limits 1 and 4 of Figure 9. The INU shall then be operated in the NAV mode for a period of not less than 10 minutes following each transient.

4.2.4.4.2 Vehicle Battery Power

a. Battery Steady State Voltage. With the normal AC and DC power inputs removed, the INU shall be operated in the NAV mode with vehicle battery power at voltages of 16.5 volts and 29.5 volts. Operation shall be for a period of not less than 10 minutes for each voltage.

b. Battery Transient Voltage. With the normal AC and DC power inputs removed, and with the INU operating in the NAV mode with vehicle battery power applied, the INU shall be tested for sensitivity to the battery transient voltages of limits 5 and 6 of Figure 9, MIL-STD-704. The INU shall then be operated in the NAV mode for a period of not less than 10 minutes following each transient.

4.2.4.4.3 Power Consumption

The AC and Vehicle Battery DC inputs shall be monitored and recorded. The Vehicle Battery DC power shall not exceed the limits shown in Table IIa. The Vehicle AC power (startup and running) shall not exceed the limits shown in Table II.

4.2.4.5 Post-Qualification Functional Test

A post-qualification functional test shall be performed in accordance with the procedures of paragraph 4.2.3.2.

4.2.5 Combined Environments Test (CET)

The purpose of the CET is to evaluate system design by obtaining engineering failure data while the system is operating in a simulated service environment. Three types of environments will be simulated: arctic, desert, and tropic. Altitude, temperature, relative humidity, and vibration shall be varied in accordance with the requirements of this specification while the INU is operating in the NAV mode. Only the tropic flights shall require humidity control. All normal INU outputs shall be monitored for compliance with the requirements of this specification during all test cycles.

4.2.5.1 Test Samples

The quantity and configuration of the test samples shall be as specified in the contract.

4.2.5.2 Test Procedure

Each test cycle shall consist of a 65 minute temperature soak, a simulated flight, a 15 minute null, and a simulated flight for a total of 480 minutes. The total test consists of 100 hours (30 simulated flights) in accordance with the schedule as shown in Table V. The profiles for temperature, altitude, relative humidity (tropic only) and vibration are shown in Figures 5 and 6A. A detailed description of the profiles is provided in Table VI. For each test condition of the CET, the INU shall be provided with the cooling air as specified in paragraph 3.3.4 herein. The vertical axis shall be the vibration axis (relative to the mounting installation) for all cycles.

4.2.6 Production Verification Test (PVT)

Production verification tests shall be conducted in accordance with the requirements specified herein to expose design deficiencies and defects due to inadequate quality control, introduction of new production lines or design changes. Each deliverable INU shall be subjected to the PVT sequence. All normal INU outputs shall be monitored for compliance with the requirements of this specification during each portion of the PVT cycle when the INU is operating.

4.2.6.1 Procedure

Figure 7 illustrates the PVT test sequence. For each test condition specified in the PVT, the INU, while operating, shall be provided with cooling air equivalent to that specified in paragraph 3.3.4 herein. The test procedure consists of the following sequence of events:

a. Random Vibration - see paragraph 4.2.6.1.1
b. Temperature Cycling - see paragraph 4.2.6.1.2
c. Acceptance Test - see paragraph 4.2.3

4.2.6.1.1 Random Vibration

As illustrated in Figure 7, the INU shall be subjected to random vibration at a minimum Power Spectral Density (PSD) of 0.04g squared per Hz, for 10 minutes in each of the three orthogonal axes illustrated in Figure 8. The INU shall be operating while being subjected to this test.

4.2.6.1.2 Temperature Cycling

Each PVT sequence shall include a minimum of 10 temperature cycles with the last three cycles failure free. Temperature cycles shall be as described in paragraph 4.2.6.1.2.1 and as illustrated in Figure 9. A survey shall be run in accordance with MIL-STD-781, paragraph 5.1.5, to establish the INU stabilization temperature.

4.2.6.1.2.1 Temperature Cycle Steps

Each PVT sequence shall consist of the following steps as illustrated in Figure 9.

1. Reduce the chamber air temperature at a minimum rate of 5 degrees Celsius per minute and stabilize the INU temperature at -54 degrees Celsius.

2. Raise the chamber air temperature at a minimum rate of 5 degrees Celsius per minute and stabilize the INU temperature at -40 degrees Celsius.

3. Turn the INU on and perform a gyrocompass alignment while raising the chamber air temperature at a minimum rate of 5 degrees Celsius per minute, but not to exceed 102 degrees Celsius per minute from -40 to +71 degrees Celsius. Switch to the NAV mode as soon as the INU transmits a "NAV RDY" status. Monitor INU performance. Minimum time in NAV mode shall be 90 minutes.

4. Upon completion of the first 90 minute navigation run, turn the INU off. As soon as the INU stabilizes at +71 degrees Celsius turn the INU on and perform a gyrocompass alignment. Switch to the NAV mode as soon as the INU transmits a "NAV RDY" status. Then reduce the chamber air temperature at a minimum rate of 5 degrees Celsius per minute but not to exceed 102 degrees Celsius per minute to -54 degrees Celsius. Monitor INU performance. Minimum time in NAV mode shall be 90 minutes.

5. Turn the INU off. Continue temperature cycling by stabilizing the INU temperature at -54 degrees Celsius. Repeat steps 2 through 4 until the required number of cycles have been completed.

6. At the end of the second NAV run of the last failure free cycle, turn the INU off and return the chamber temperature to ambient.

4.2.6.2 Failure and Retest Criteria

A failure for PVT is defined as the inability of the INU to perform its prescribed function within specified tolerances.

4.2.6.2.1 Failure Necessitating INU Retest During PVT

a. There shall be no adjustment, replacement, or repair of a part or assembly within the INU during the failure free period (see Figure 7).

b. The need to reprogram the INU shall be classified as a failure.

c. Failures which are directly attributed to technician error made during test or test equipment malfunction, which do not require replacement or repair of a part or assembly may not require a repeat of completed PVT cycles. The government shall determine if completed cycles shall be repeated.

d. Navigation accuracy errors greater than the following shall require a restart of the PVT:

   (1) 1.0 nmi/hr CEP for the 20 navigation runs in the 10 cycle PVT. (See Paragraph 6.2 for the method of calculating CEP.)

   (2) Any error within a single navigation run exceeding an envelope bounded by 1.25 nmi position error during the first 15 minutes and 5.0 nmi/hr position error rate for the remainder of the navigation run. ALL position error rates shall be referenced to the time that the NAV mode is entered.

Table V - Combined Environments Test

CYCLE	TEMPERATURE SOAK (DEGREES CELSIUS)	TYPE CYCLE
1	71	Desert
2	50	Desert
3	50	Tropic
4	50	Desert
5	50	Desert
6	50	Tropic
7	4	Arctic
8	4	Arctic
9	4	Arctic
10	-40	Arctic
11	4	Arctic
12	4	Arctic
13	50	Desert
14	50	Desert
15	50	Tropic

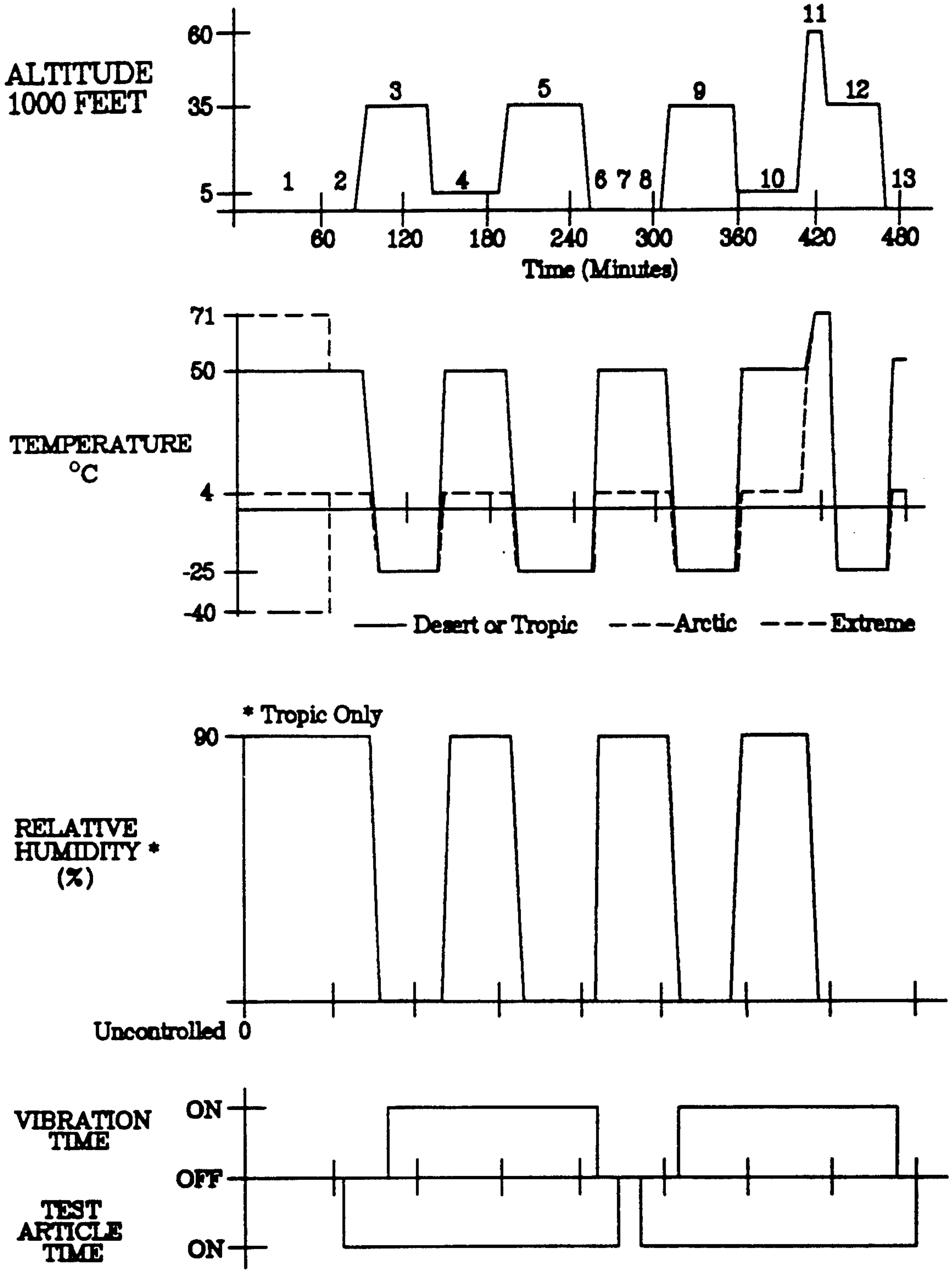


Figure 5
Combined Environments Test Profiles

Table VI - Combined Environments Test Profiles

	STEP #	TIME INTERVAL (minutes)	ALTITUDE (1000 FT)	DESERT TEMP °C	DESERT HUMID % RH	ARCTIC TEMP °C	ARCTIC HUMID % RH	TROPIC TEMP °C	TROPIC HUMIDITY % RH	VIBRATION g^2/Hz
SOAK TEMP	1A	0 to 65	ambient	71		-40		--	--	0
	1B	0 to 65	ambient	50		4		50	>90	0
SIMULATED FLIGHT	2	65 to 90	ambient	50	UNCONTROLLED	4	UNCONTROLLED	50	>90	0
	3	95 to 140	35	-25		-25		-25	uncontrolled	0.02
	4	145 to 190	5	50		4		50	>90	0.02/0.04*
	5	195 to 250	35	-25		-25		-25	uncontrolled	0.02
	6	255 to 265	ambient	50		4		50	>90	0
OFF	7	265 to 280	ambient	50		4		50	>90	0
SIMULATED FLIGHT	8	280 to 305	ambient	50		4		50	>90	0
	9	310 to 355	35	-25		-25		-25	uncontrolled	0.02
	10	360 to 405	5	50		4		50	>90	0.02/0.04*
	11	410 to 420	60	70		70		70	uncontrolled	0.02
	12	425 to 465	35	-25		-25		-25	uncontrolled	0.02
	13	479 to 480	ambient	50				50	uncontrolled	0

* See footnotes on Figure 6A

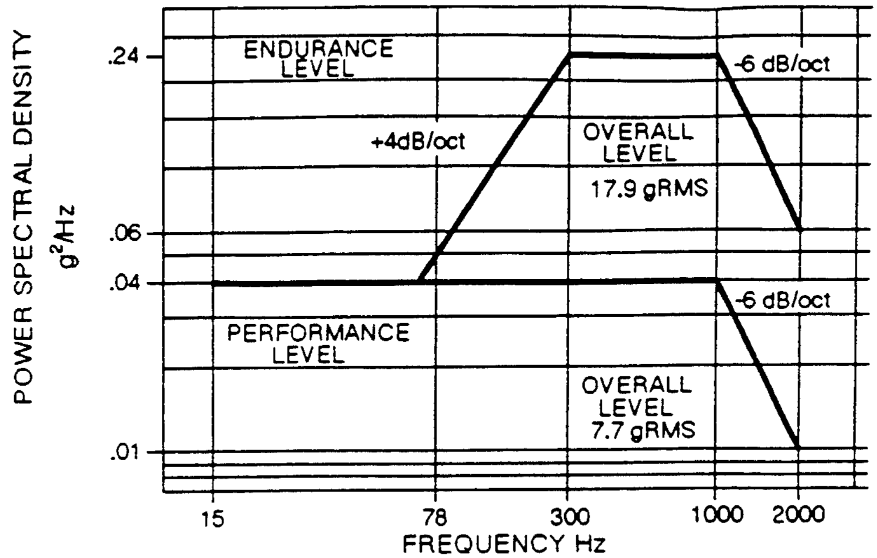


Figure 6
Random Vibration Test Levels

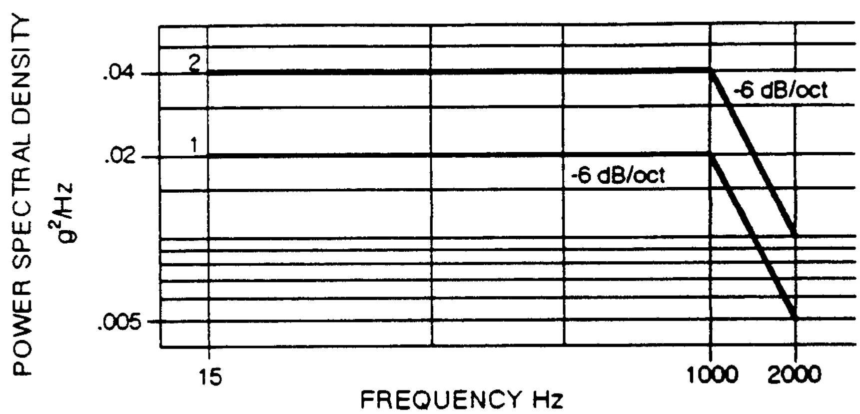


Figure 6A
CET Random Vibration Test Levels

Notes:

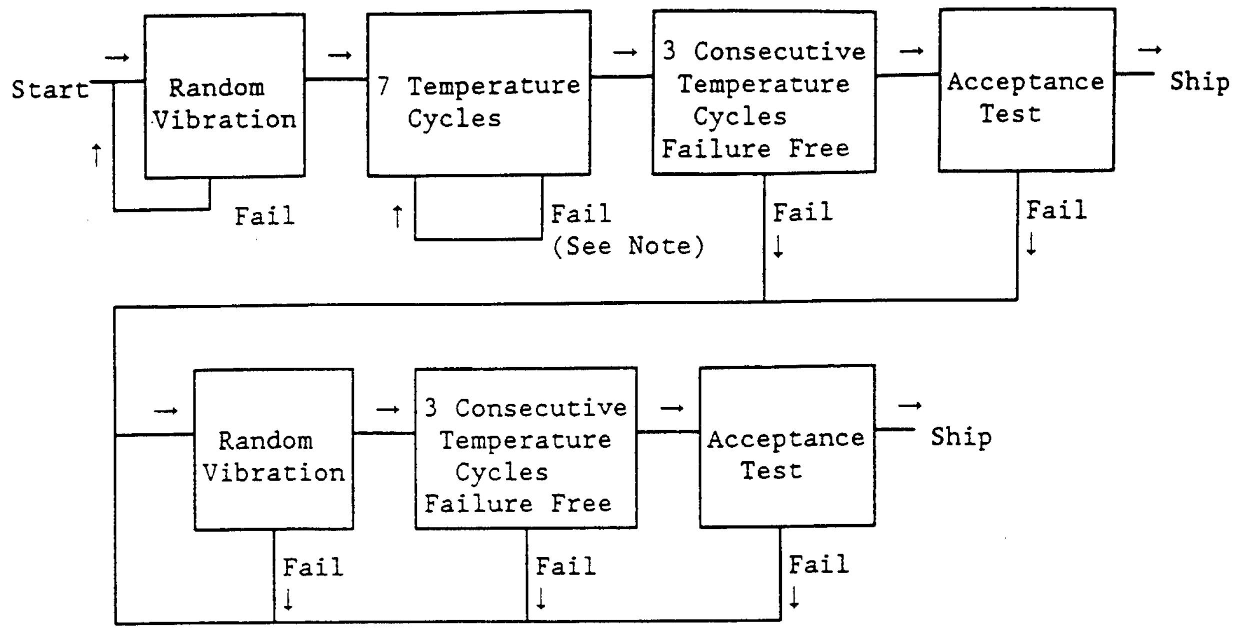
1. In reference to Figure 5 and Table VI, the vibration during ascending altitude phases is 0.04 g^2/Hz and during descending phases is 0.02 g^2/Hz.

2. Curve 1 to be run during all INU on-times except as specified below (Reference Figure 5).

3. Curve 2 to be run during all ascending altitude segments of the flight profile and during each 5,000 ft altitude segment as detailed below.

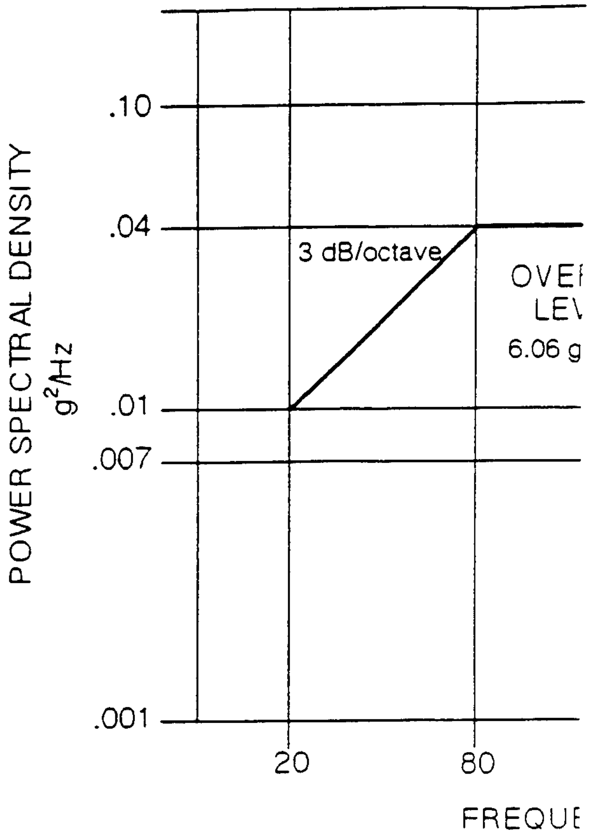
   a. CET, in addition to vibration qualification (4.2.4.2.3) - Curve 2 to be run 5 minutes during each 5,000 ft altitude segment for a total of 10 minutes per 8 hour CET cycle.

   b. CET, in lieu of vibration qualification (4.2.4.2.3) - Curve 2 to be run throughout each 5,000 ft altitude segment for a total of 110 minutes per 8 hour CET cycle.



Note: A failure during any of the first 7 temperature cycles requires only a successful repeat of the failed cycle(s).

Figure 7
Production Verification Test Sequence



.10
.04
.01
.007
.001
POWER SPECTRAL DENSITY
g^2/Hz
3 dB/octave
OVE
LE
6.06 g
20
80
FREQU

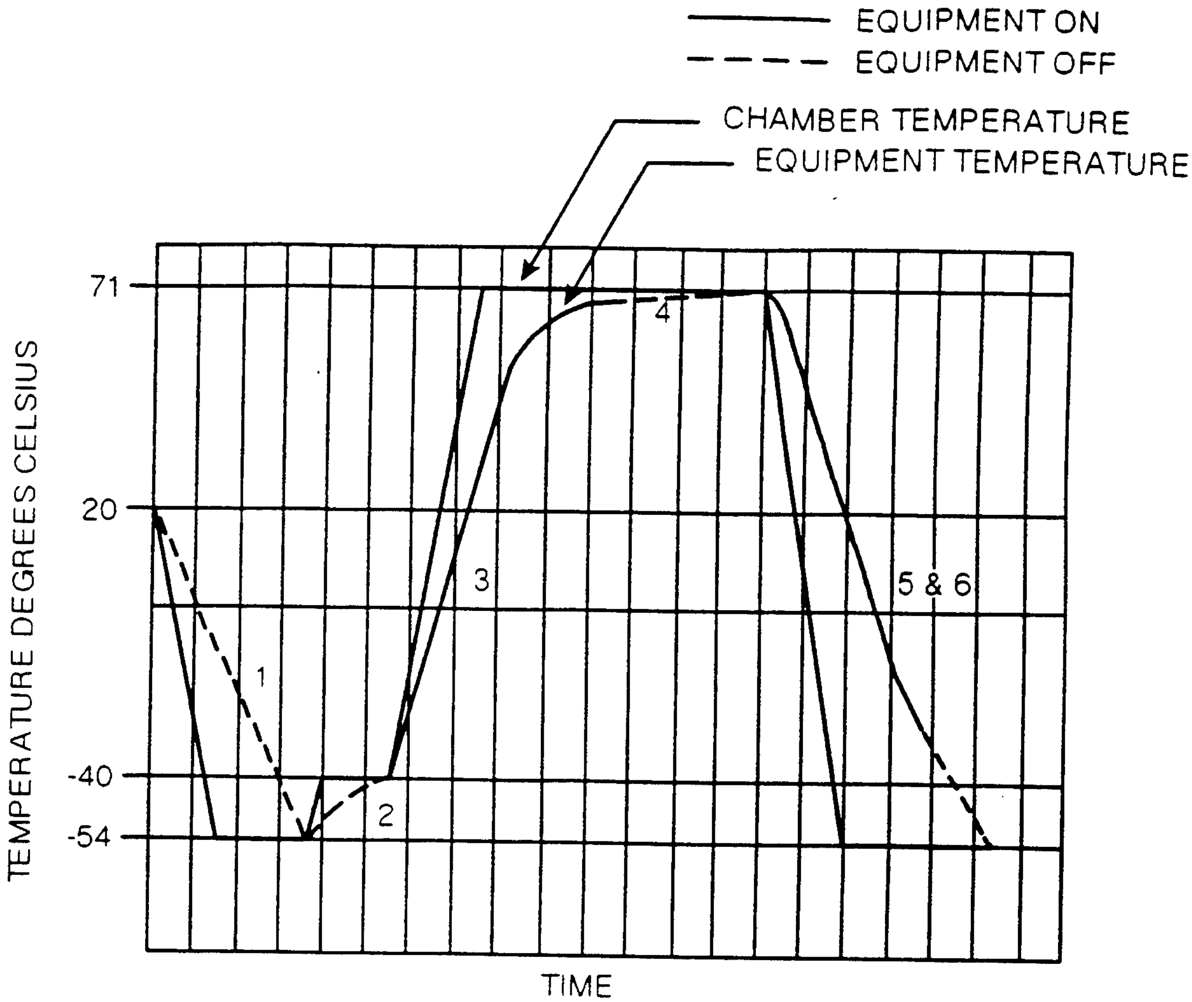


Figure 9
Single PVT Temperature Cycle

4.2.6.2.2 Retest Criteria

Any system which fails while attempting to satisfy the PVT failure free requirements including final acceptance testing shall be required to restart the PVT procedure except as specified in paragraph 4.2.6.2.1.

4.2.6.2.3 PVT Trial Cycles

Any system which fails during PVT cycling or acceptance testing may, at the option of the test supervisor, be submitted to PVT or burn-in type trial cycles for troubleshooting or to verify the validity of any repairs performed. Failures occurring during these trial cycles shall be recorded by the contractor, but shall not be included in the customer failure reporting documents. Prior to start of the trial cycle, the log shall identify the cycle and associated data as "Trial Cycle".

4.2.6.3 Failure Reporting and Analysis

All failures occurring after the system has started the PVT shall be reported and analyzed. A summary of all failures shall be provided to the government as required in the contract.

4.2.6.3.1 Test Log Book

All failures during the Production Verification Test Sequence, after completion of the contractor burn-in, shall be recorded. A test log book shall be maintained for each INU and shall accompany it throughout the test period. Each page of the log reviewed by the customer shall be signed or stamped by a customer representative.

4.2.7 Maintainability/BIT Demonstrations

4.2.7.1 General

Compliance with the requirements of this specification for maintainability/BIT will be demonstrated through the testing outline below. The testing to determine compliance will be integrated with other quality assurance tests as applicable.

4.2.7.2 Maintainability Demonstration

Compliance with the requirements of paragraph 3.2.4.2 (excluding Equipment Repair Time (ERT) and maximum maintenance time (Mmax) requirements) shall be assessed by inspection (observation) during the maintainability demonstrations delineated in paragraph 4.2.7.2.1 and 4.2.7.2.2. The procuring activity shall reserve the right to provide and/or select the technicians to perform organizational and intermediate maintenance level demonstrations. The contractor will provide adequate training to qualify the customer's technician(s) to perform the maintainability demonstrations. The technical documentation to be used shall be limited to the equipment technical manuals. Where practical, two or more INUs shall be used during the demonstrations in order to assess the interchangeability of the equipment.

4.2.7.2.1 Organizational Level

A demonstration of organizational level maintainability requirements (excluding INU fault location) shall be accomplished and shall simulate as closely as practical the organizational scenario.

a. The demonstration shall include the following organizational level maintenance tasks:

   (1) Removal and replacement (not including vehicle access time).

   (2) Checkout of repair.

b. The Organizational Level Equipment Repair Time (ERT) acceptance criterion shall be in accordance with MIL-STD-471, Test Method 4.

4.2.7.2.2 Intermediate Level

An intermediate level maintainability demonstration shall be conducted in accordance with MIL-STD-471, Notice 1, Method 9, to verify the requirements specified in paragraph 3.2.4.2.2. The sample size and fault selection shall be in accordance with MIL-STD-471.

4.2.7.3 Failure Detection

Data to determine degree of compliance with the requirements of paragraph 3.2.4.3.1 shall be obtained from two sources by recording INU BIT capability to correctly indicate, or failure to indicate, the existence of an INU malfunction as follows:

a. When sample failures are introduced in accordance with the Intermediate Level demonstration specified in paragraph 4.2.7.2.2 above.

b. During the combined environments test (paragraph 4.2.5) and production verification test (paragraph 4.2.6) specified herein.

4.2.7.4 Failure Location

Vendors shall maintain a record of all failures occurring or introduced into the INU during the maintainability demonstrations, combined environments tests, and production verification tests required in this specification. At each failure event or malfunction, the BIT capability to locate the source of the failure to the INU and the SRU will be recorded. In the event the BIT circuitry fails, or is unable to detect or locate an equipment failure, an analysis shall be made and documented. From these data, equipment compliance with the requirements of paragraph 3.2.4.3.2 will be determined.

4.2.8 Replacement and Spare SRU/Modules

Replacement and spare SRUs and modules shall be tested by subjecting all SRUs/modules to the PVT series of tests.

5. PREPARATION FOR DELIVERY

5.1 General

The INU shall be packaged, packed and marked for delivery in accordance with the applicable purchase order. Packing shall be adequate for the type and conditions of shipment.

6. NOTES

6.1 Position Accuracy

The military navigation position accuracy is based on terminal radial position error. The terminal radial position error is measured as the magnitude of the horizontal position error, in terms of North/East components, between the pure inertial latitude/longitude and the terminal base latitude/longitude. The Radial Error Rate (RER) is the calculated radial position error divided by total navigation time. The Circular Error of Probability (CEP) for each flight is based on 0.83 times the terminal RER for that flight. 0.8 nmi/h (1.48 km/h) CEP (50th percentile) converts to 1.7 nmi/h (3.1 km/h) on a 95 percentile basis.

6.2 PVT Navigation Accuracy

The RER for each mission/cycle is calculated as the slope of a straight line best fit, forced through the origin at time zero, to the plotted radial position error versus time curve. The PVT navigation accuracy is then based on the Root Mean Square (RMS) of the total ensemble of RERs as a function of the number of missions/cycles. The CEP is calculated as follows:

$$CEP = 0.83\left[\frac{1}{n}\sum_{i=1}^{n}(RER_i)^2\right]^{1/2}$$

where: RER_i is the i^{th} mission RER.

n is the total number of mission RERs.

6.3 Velocity Accuracy

The intent of specifying an RMS number here was to warrant that 68 percent of the data taken would fall within the specified limit. Further, the RMS is taken over an ensemble of time so that the maximum RMS number is always met within the first two hour period. For purposes of analysis, a perfect barometric input of zero will be assumed here. The following equation may be used for making time RMS calculations.

$$\text{RMS Velocity} = \left[\frac{1}{mn}\sum_{k=1}^{m}\sum_{i=1}^{n}(V_k(t_i))^2\right]^{1/2}$$

where: $V_k(t_i)$ = velocity of the k^{th} run as a function of time, t_i.

t_i is equally spaced across time and k is the index across the ensemble of runs.

n is total number of data points per run and m is the total number of data runs.

6.4 Coordinate Frame Definitions

The coordinate frames used in this specification are defined in this section. These frames are right hand and orthogonal systems. The signs of rotations that occur within these frames are defined by the right hand rule unless specifically defined to the contrary. The reference ellipsoid used in defining these frames and the relationships between them will be the one defined in WGS-84 (see section 6.6).

Several coordinate frames have their origin at a point called the computed specific force origin. This point is the point in the instrument cluster from which the INU manufacturer computes accelerations, velocities, and translations.

6.4.1 Earth-Centered Earth-Fixed Frame (E Frame: Xe, Ye, Ze)

The origin is located at the mass center of the earth. Xe is directed north along the polar axis. Ye and Ze are in the equatorial plane with Ze directed through the Greenwich meridian, and Ye directed through 90 degree W longitude. Geographic position denoted in terms of geodetic latitude (phi), longitude (lambda), and altitude (h), is defined with respect to the earth-centered, earth-fixed system as shown in Figure 10.

6.4.2 Local Geodetic Frame (G Frame: Xg, Yg, Zg)

The origin is located at the computed specific force origin. Xg and Yg are in a plane parallel to a plane that is tangent to the reference ellipsoid at the geographic location of the INU, with Xg pointed north and Yg pointed west. Zg is perpendicular to the ellipsoid and pointed up (see Figure 10).

6.4.3 Navigation Frame (N Frame: X, Y, Z)

The origin is located at the computed specific force origin. Z axis is aligned with Zg and X and Y are in the same plane as Xg and Yg (see Figure 10). The angle from Xg to X is defined as wander angle (alpha). Its initial value is determined by the INU manufacturer's particular mechanization. Its time rate of change however is governed by the following equation:

(alpha)' = [-(lambda)'][sin(phi)]

NOTE: This is the only frame used in this specification whose axes are not subscripted (see Figure 11).

6.4.4 "Sensor" Frame (S Frame: Xs, Ys, Zs)

The purpose of this coordinate frame is to allow an external filter to model, identify, and correct the instrument errors. A secondary purpose is to provide convenient access to body coordinates since the sensor coordinates are identical to aircraft body coordinates in the case of a strapdown system. The sensor coordinate frame is defined as follows:

a. In the case of a local level gimbaled system, sensor coordinates are identical to navigation reference frame coordinates.

b. In the case of strapdown systems, sensor coordinates are identical to aircraft body coordinates.

This definition should not be construed as constraining the input axes of the actual inertial instruments to these axes. The intent is that the filter will model "analytic" inertial instruments whose axes may have some fixed offset from the actual instrument axes, and consequently whose errors will be linear combinations of the actual instruments errors.

6.4.5 Gyro Frame (O Frame: Xo, Yo, Zo)

The origin is translated to/located at the computed specific force origin. The Xo axis is aligned with the X-gyro input axis, and the Yo and Zo axes are orthogonal and aligned as closely to the Y and Z-gyro input axes as possible.

6.4.6 Accelerometer Frame (A Frame: Xa, Ya, Za)

The origin is located at the computed specific force origin. The Xa axis is aligned with the X-accelerometer input axes, and the Ya and Za axes are orthogonal and aligned to the Y and Z-accelerometers input axes as closely as possible.

6.4.7 Chassis Frame (R Frame: Xr, Yr, Zr)

The chassis frame is defined relative to the mounting pins on the rack. The center of the diamond mounting pin (see Figure 13) as it emerges from the mounting surface at the rear of the rack defines the origin of the coordinate frame. The Xr axis is defined from this point towards the center of the round mounting pin at the rear of the rack. The Yr axis is defined as the axis of the diamond mounting pin. The Zr axis forms a right hand orthogonal frame with Xr and Yr.

6.4.8 Aircraft Body Frame (B Frame: Xb, Yb, Zb)

The origin is located at the computed specific force origin. Xb is out the nose, Yb is out the right wing, and Zb is out the belly of the aircraft (see Figure 12).

6.5 Coordinate Frame Transformations

The relationships between the coordinate systems used in the INU are conveyed by either direction cosine matrices (DCMs) or Euler angles which can be used to create DCMs. The transformations in this section and their inverses, when used in combination, allow vectors to be transformed between any two frames of interest. Since each of the DCMs is orthogonal, the inverse transform can be obtained by simply taking the transpose of the appropriate matrix, i.e. the inverse of CAB is the transpose of CAB. The DCM's output by the standard INU contain the first two rows only. The user can obtain the third row by computing the cross product of the first two. In this section, the following symbols are used:

alpha	= wander angle (platform azimuth - true heading)
phi	= latitude
lambda	= longitude
psiAZ	= platform azimuth
psiTH	= true heading

Both psiAZ and psiTH are available directly in data blocks I01, I06/I08, or IH1. Lambda is available in data block I01. Phi must be derived from the data in I01 or I10 by phi = arcsin(CNExz). Alpha must also be derived from the same data by alpha = arctan(-CNExy/CNExx). Note: Care shall be taken to maintain the correct sign. An alternative (with reduced accuracy for gimbaled systems due to resolver resolution) is to use the data in I01, I06/I08, or IH1 with alpha = psiAZ - psiTH.

6.5.1 Chassis Frame to Aircraft Body Frame

The relationship between these two frames is given by three Euler angles which are sent from the aircraft to the INU in the miscellaneous parameters in D01. This information is used internally in the INU and output in I13 for comparison purposes.

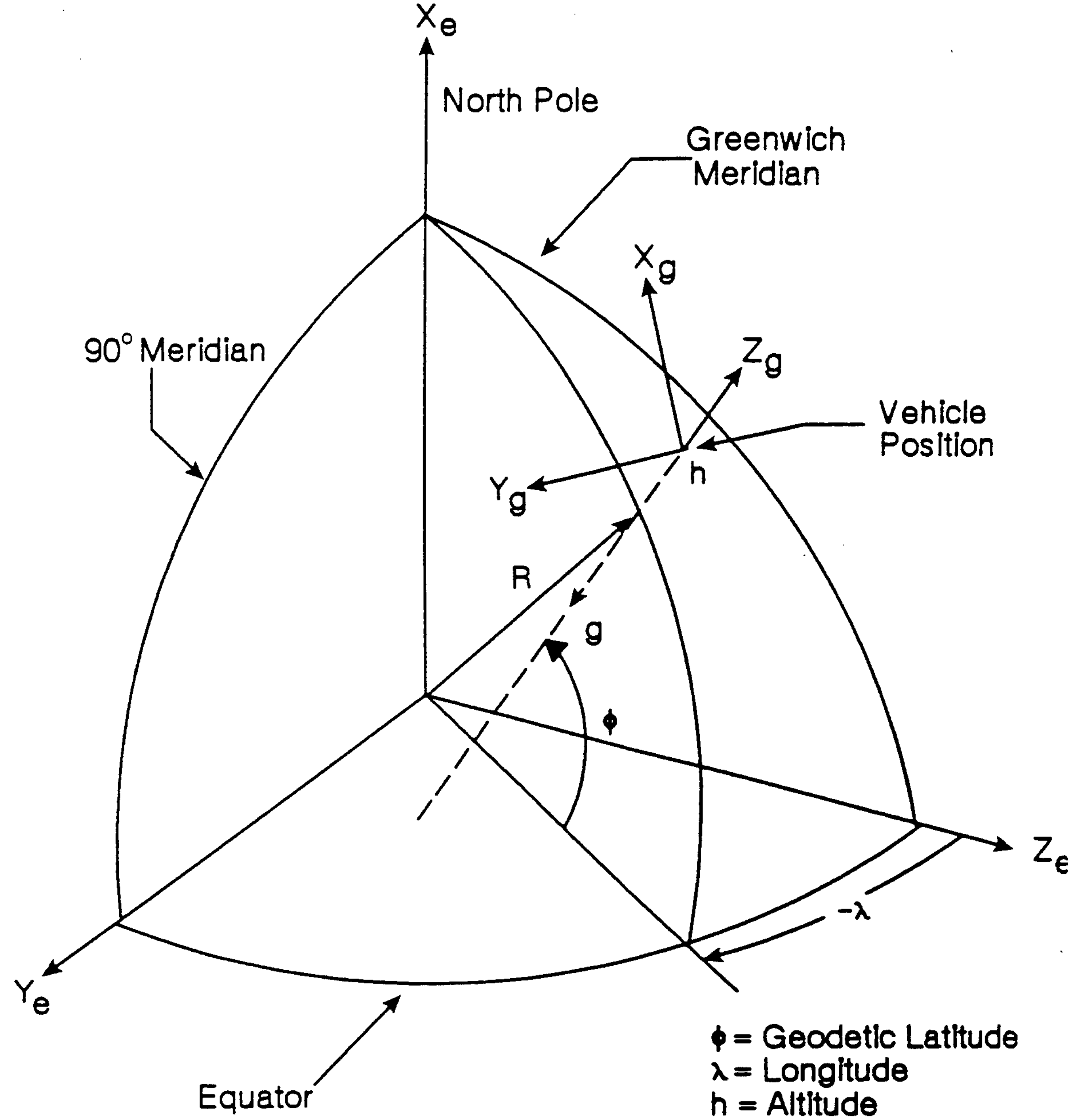
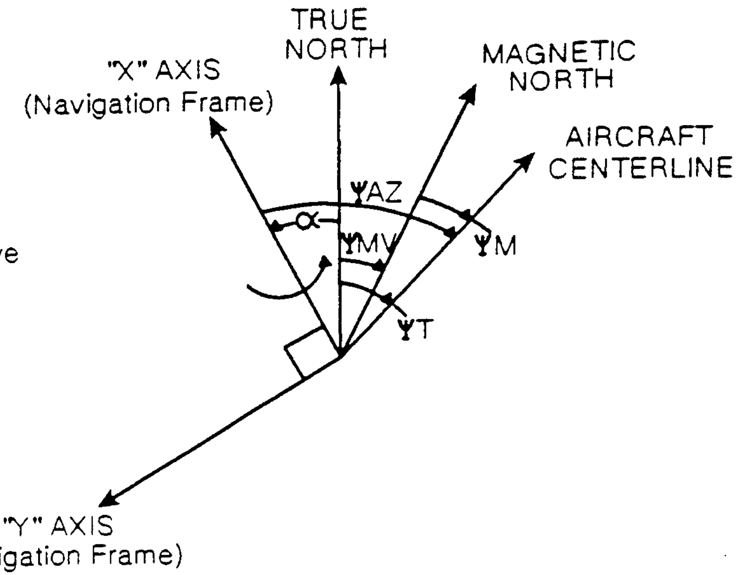


Figure 10
Earth Centered, Earth Fixed Coordinate System

Ψ_{AZ} = Platform Azimuth
Ψ_T = True Heading
Ψ_{MV} = Magnetic Variation
Ψ_M = Magnetic Heading
α = Wander Angle
"Z" platform axis is positive when directed up

Latitude is positive in the Northern Hemisphere



Θ_{SC} = Selected Magnetic Course
Ψ_G = True Ground Track
Ψ_B = Steerpoint True Bearing
Θ_{RB} = Steerpoint Relative Bearing
Θ_{SE} = Great Circle Steering Error
Θ_{CD} = Course Deviation (positive when steering bar is to the right - a steer to the right is commanded)

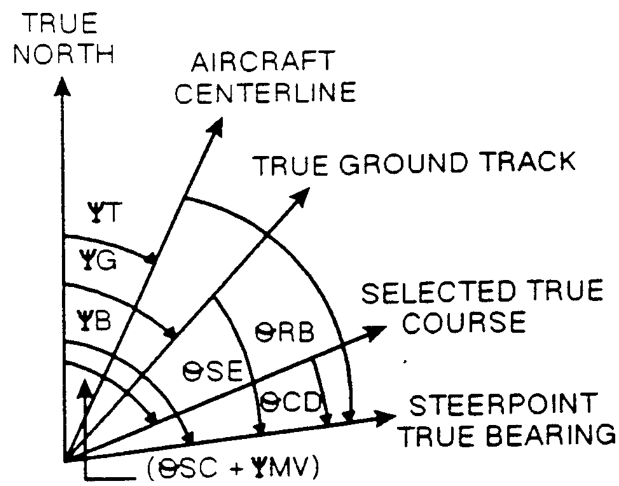
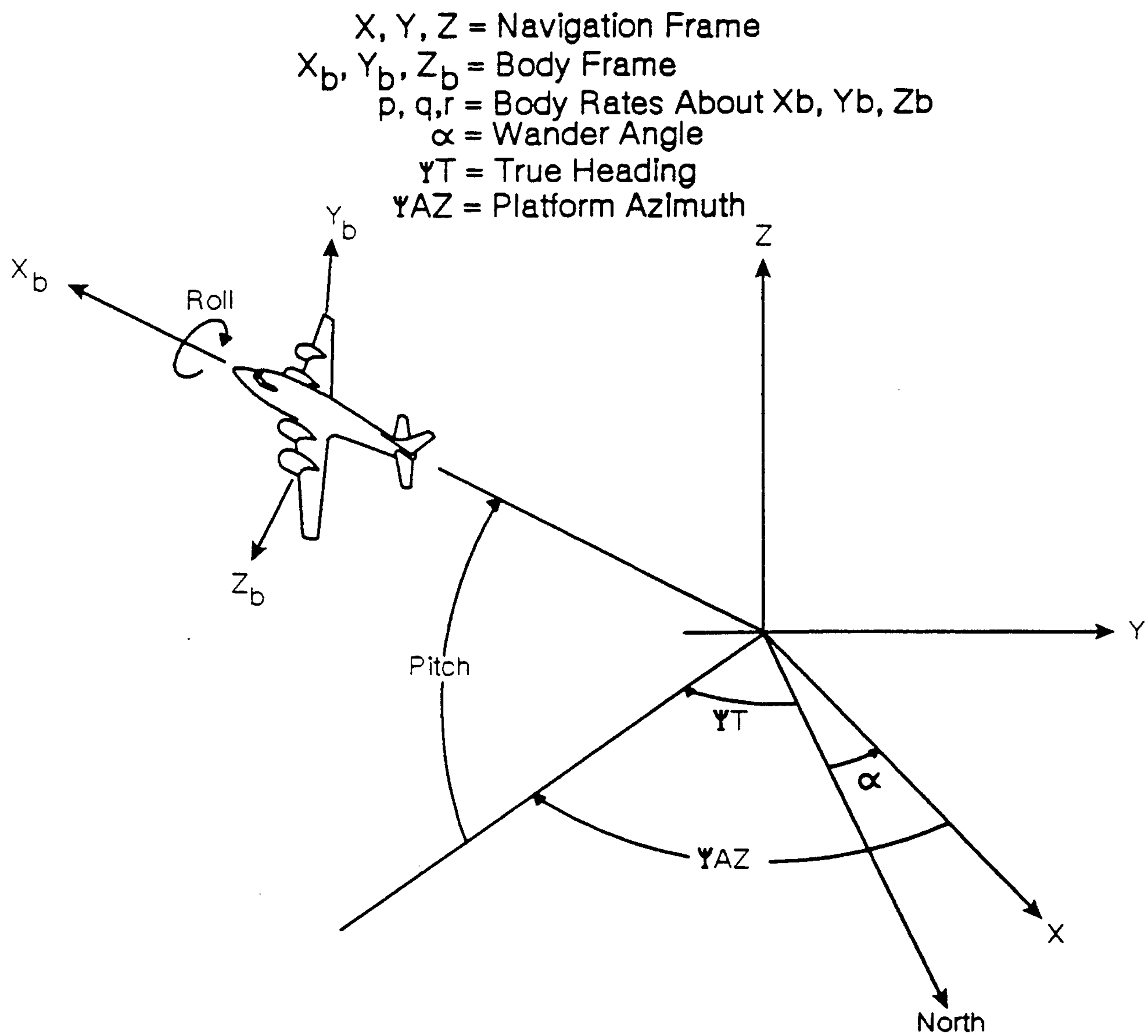


Figure 11
Definition of INU Azimuth Angles



Note: **Origin of body frame displaced from that of nav frame only for clarity of diagram, they are actually coincident at the INU computed specific force origin (see paragraph 6.4.3).**

Figure 12
Navigation and Body Coordinate Frames

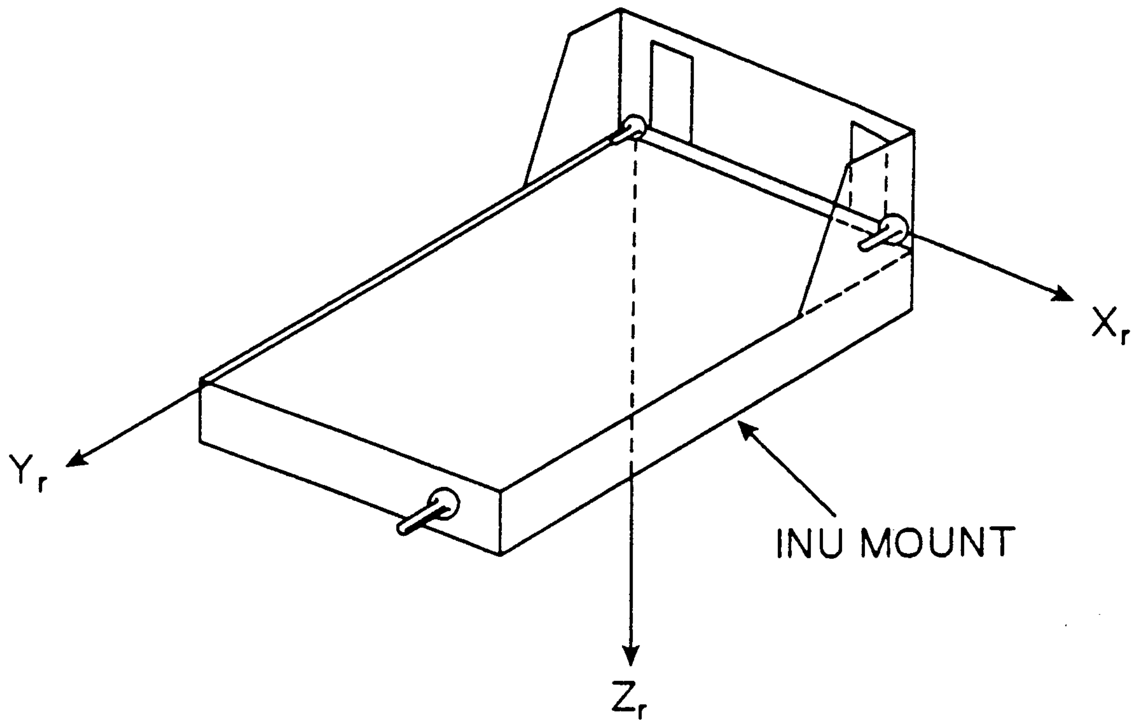


Figure 13
Definition of the Chassis Axis (R Frame: X_r, Y_r, Z_r)

6.5.2 Aircraft Body Frame to Navigation Frame (CBN)

In the case of the strapdown INU this DCM is provided as CSN in data block I10. For a gimbaled system, it must be created from the platform Euler angles in data blocks I01, I06, or I08 using the following equations:

CBNxx = cos(psiAZ)*cos(pitch)

CBNxy = cos(psiAZ)*sin(pitch)*sin(roll) - sin(psiAZ)*cos(roll)

CBNxz = cos(psiAZ)*sin(pitch)*cos(roll) + sin(psiAZ)*sin(roll)

CBNyx = -sin(psiAZ)*cos(pitch)

CBNyy = -sin(psiAZ)*sin(pitch)*sin(roll) - cos(psiAZ)*cos(roll)

CBNyz = cos(psiAZ)*sin(roll)-sin(psiAZ) * sin(pitch)*cos(roll)

CBNzx = sin(pitch)

CBNzy = -cos(pitch)*sin(roll)

CBNzz = -cos(pitch)*cos(roll)

6.5.3 Aircraft Body Frame to Local Geodetic Frame (CBG)

This DCM is not provided. It can be created by using the platform Euler angles in data blocks I01, I06, or I08. Use the equations in 6.5.2 but substitute psiTH for each occurance of psiAZ.

6.5.4 Sensor Frame to Navigation Frame (CSN)

This frame is provided in data block I10.

NOTE: CSN = I (the Identity matrix) for local level gimballed systems.
CSN = CBN for strapdown systems.

Read paragraph 6.4.4 for details.

6.5.5 Accelerometer Frame to Sensor Frame

Three Euler angles are provided in data block I13 to relate these two frames.

6.5.6 Gyro Frame to Sensor Frame

Three Euler angles are provided in data block I13 to relate these two frames.

6.5.7 Navigation Frame to Local Geodetic Frame (CNG)

This DCM is not provided. It can be created from the following equations:

CNGxx = cos(alpha)

CNGxy = -sin(alpha)

CNGxz = 0.0

CNGyx = sin(alpha)

CNGyy = cos(alpha)

CNGyz = 0.0

CNGzx = 0.0

CNGzy = 0.0

CNGzz = 1.0

6.5.8 Navigation Frame to Earth-Centered Earth-Fixed Frame (CNE)

The first two rows of this DCM are provided in data block I10. The DCM is composed of the following elements:

CNExx = cos(alpha)*cos(phi)

CNExy = -sin(alpha)*cos(phi)

CNExz = sin(phi)

CNEyx = sin(alpha)*cos(lambda) + cos(alpha)*sin(phi)*sin(lambda)

CNEyy = cos(alpha)*cos(lambda) - sin(alpha)*sin(phi)*sin(lambda)

CNEyz = -cos(phi)*sin(lambda)

CNEzx = sin(alpha)*sin(lambda) - cos(alpha)*sin(phi)*cos(lambda)

CNEzy = cos(alpha)*sin(lambda) + sin(alpha)*sin(phi)*cos(lambda)

CNEzz = cos(phi)*cos(lambda)

6.6 Geodetic Constants

The WGS-84 reference ellipsoid, earth rate, and gravity constants are to be used in all applicable places in the INU software. The exceptions allowed include the software that produces the UTM coordinate data, and special gravity models for precision navigators.

6.7 Definitions

6.7.1 INU Data

INU Data is defined to be that information required to be output from the INU. Thus, data is not raw, uncompensated, unprocessed, instantaneous sensor or gimbal signals. Data is compensated sensor signals averaged over the sample window (Not true for velocity).

6.7.2 Data Validity Point

The Data Validity Point is defined to be the time at which the sensor is strobed and the beginning of the computational cycle (i.e., sample window) for the INU data of interest. This computational cycle is also called the "refresh rate". This point is also the point sent in the Time Tag.

6.7.3 Data Response Time

The Data Response Time is defined as the slope of the input to output phase curve at zero frequency. The phase shift is to include filter induced phase shifts as well as sampling, transport, and computational delays. Time delay is the difference between the time at which motion is input to the system and the time at which it is available in the output buffer. The Data Response Time does not include data bus transmission delays nor those due to asynchrous data bus operation.

6.7.4 Jitter

Jitter is defined as the RMS of the output about a least mean squared straight line fit of the output over a 10 second period with a sample rate equal to the transmission rate. For verfication, and testing, the measured jitter values shall be less than the following:

$$JITTER_{measured} \leq [(JITTER\ SPEC)^2 + (LSB)^2/12]^{\frac{1}{2}}$$

6.7.5 Bandwidth

Bandwidth is defined as the frequency where the output falls 3dB from its low frequency (near DC) value. Bandwidths specified in Table I are minimums.

6.8 Align Time

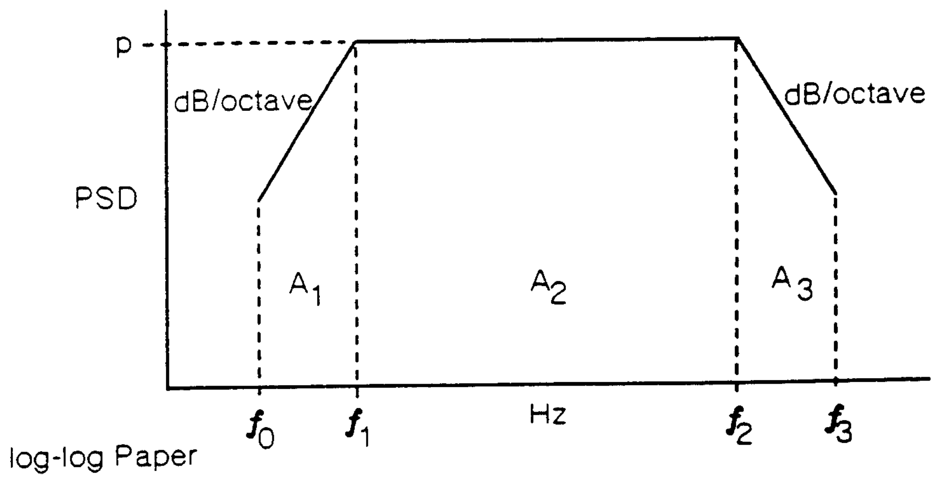
This INU function is to indicate to the maintenance person when the system was switched from align to navigate to preclude having a system being pulled and later retesting OK because the operator switched to NAV mode before gyrocompass alignment was completed. Align time and align events status when the system was switched to NAV will be stored in the computer and made available via the Miscellaneous Parameters function for later examination. These values shall be updated on the next align to nav or align to attitude transition. In addition, the INU has the capability to count and store the number of times the unit is cycled ON and OFF. This data will be used to make an operational reliability assessment.

6.9 Cooling Air Conditions

The minimum and maximum abnormal supply air temperatures are transient in nature. The normal supply temperatures occur when the vehicle ECS is functioning properly. The abnormal supply temperatures occur when ram air is supplied to the INU because of a failure in the vehicle ECS, and during initial cool-down or heat-up.

6.10 Vibration

The method for calculating overall gRMS levels for random vibration spectrums follows (reference: Tustin Institute of Technology, Revised 1972):



A = Area Under Each Exponential Curve (gRMS^2)

P = PSD Level in Flat Region (g^2/Hz)

R = Rolloff Rate (dB/octave)

Let: $Z_1 = \frac{R}{3} + 1$, with respect to A_1

$Z_3 = \frac{R}{3} - 1$, with respect to A_3

Then: $$A_1 = \frac{Pf_1}{Z_1}\left[1 - \left(\frac{f_0}{f_1}\right)^{Z_1}\right]$$

$$A_2 = P\left(f_2 - f_1\right)$$

$$A_3 = \frac{Pf_2}{Z_3}\left[1 - \frac{1}{\left(\frac{f_0}{f_1}\right)^{Z_3}}\right]$$

$$\text{gRMS} = (A_1 + A_2 + A_3)^{1/2}$$

Caution: When R = 3, then let $A_3 = 2.3\ Pf_2 \log f_3/f_2$

6.11 INU Vendor Identification Resistors

Identification of the vendor INU by Automated Test Equipment shall be accomplished by a resistive load being placed between pins 44 and 45 of connector P-132. The following resistive loads shall identify vendors:

VENDOR	LOAD (OHMS)
Rockwell Collins Division	OPEN
Delco	1000
General Electric	2000
Hamilton Standard	3000
Honeywell	4000
Lear Siegler	5000
Litton Guidance and Control Systems Division	6000
Litton Aeroproducts Division	7000
Northrop	8000
Raytheon	9000
Rockwell Autonetics Division	10000
Kearfott Guidance & Navigation Corporation	11000
Sperry	12000
Teledyne	13000

6.12 Glossary

AC	Alternating Current
A/C	Aircraft
ADI	Attitude Direction Indicator
Amp-sec	Ampere - second
ATT	Attitude
AZ	Azimuth
BATH	Best Available True Heading
BCD	Binary Coded Decimal
BIT	Built-In-Test
BNR	Binary
BRG	Bearing
°C	degrees Celsius
CADC	Central Air Data Computer
CAL	Calibration
CBG	Aircraft Body frame to local Geodetic frame
CBN	Aircraft body frame to Navigation frame
CC	Central Computer
CDU	Control Display Unit
CEP	Circular Error Probable
CET	Combined Environments Testing
CIGTF	Central Inertial Guidance Test Facility
cm	centimeter
CNE	Navigation frame to Earth Centered - Earth fixed frame
CNG	Navigation frame to local Geodetic frame
CSN	Sensor frame to Navigation frame
Cum	Cumulative
CW	Clockwise
DC	Direct Current
DCM	Direction Cosine Matrix
deg	degree(s)
DEST	Destination
E	East
ECS	Environmental Control System
EMI	Electromagnetic Interference
ER	Established Reliability
ERT	Equipment Repair Time
F^3	Form, Fit and Function
FC	Flight Control
FD	Failures Detected
FFI	False Failure Indication
FMB	Filter Mode Bit
fps	feet per second
ft	feet
g	unit of gravity
GC	Gyro Compass
GPS	Global Positioning System
h	hour
Hdg	Heading
HOL	High Order Language
HSI	Horizontal Situation Indicator

Glossary (continued)

HUD	Heads-Up-Display
Hz	Hertz
INU	Inertial Navigation Unit
INS	Inertial Navigation System
I/O	Input/Output
km	kilometer
kHz	kilohertz
L/L	Latitude/Longitude
lbs	pounds
LMD	Left Miscellaneous Display
LRU	Line Replaceable Unit
LSB	Least Significant Bit
LSC	Least Significant Character
LSD	Least Significant Digit
LSP	Least Significant Part
m	meter
M	Mach number
Mag	Magnetic
mg	milli 'g' (unit of gravity)
MH	Magnetic Heading
MHz	Megahertz
min	minute
MISC	Miscellaneous
MP	Markpoint
ms	millisecond
MSB	Most Significant Bit
MSC	Most Significant Character
MSD	Most Significant Digit
MSP	Most Significant Part
MTBF	Mean Time Between Failures
MUB	Mass unbalance
MUX	Multiplex
MV	Magnetic Variation
N	North
N/A	Not Applicable
NARF	Navigation-Alignment Refining Feature
NAV	Navigation
nmi	nautical mile
OFP	Operational Flight Program
p/p_o	Ratio of ambient static pressure to standard sea level pressure
P-P	Peak-to-Peak
pi rad	pi radians
PPOS	Present position
PSD	Power Spectral Density
psia	pounds per squared inch absolute
PVT	Production Verification Test
rad	radians
RB	Relative Bearing
RDY	Ready
REF	Reference
RER	Radial Error Rate

Glossary (continued)

rho/rho_o	Ratio of ambient air density to standard sea level air density
R.H. WRT	Right Hand With Respect To
RMD	Right Miscellaneous Display
RMS	Root Mean Squared
RT	Receive - Transmit
S	South
s	second
SE	Support Equipment
sec	second(s)
SH	Stored Heading
SOF	Safety Of Flight
Sph	Spheroid
SRU	Shop Replaceable Unit
STBY	Standby
STR-PT	Steering Point
TB	True Bearing
TBD	To Be Determined
TH	True Heading
TTL	Transistor Transistor Logic
T/R	Transmit/Receive
UTM	Universal Transverse Mercator
VA	Volt-Ampere
VAC	Volts AC
VDC	Volts DC
W	West
WGS	World Geodetic Survey
WP	Waypoint
WRT	With Respect To

APPENDIX I

INU INPUT SIGNAL INTERFACES

(SERIAL DIGITAL)

Table I-1

INU Digital Signal Interface Inputs

SIGNAL	UNITS	REQUIRED RANGE	POSITIVE DIRECTION	REMARKS
CDU/INU Control Word 1	---	---	---	D01-01
CDU/INU Control Word 2	---	---	---	D01-02
UTM Spheriod	ASCII Codes	0 - 9 A,B	---	D0-03 (MSB), Format II
UTM Grid Zone Designation	2 numeric 1 alpha	0-60 A-Z	---	D01-03 (LSB) & D01-04, Format II
100,00 Meter UTM Area	2 alpha	A-Z	---	D01-05, Format II
UTM Easting	meters	0-99998	---	D01-06, Format II
UTM Northing	meters	0-99998	---	D01-07 Format II
Selected Magnetic Course to Steerpoint	degrees	0-359.9	CW WRT MAG North	D01-03, Format V
Convergence Factor	---	0-1.00000	---	D01-03, Format VIII
CC/INU Mode Word	---	---	---	F02-01
CNEXX	none	±1	---	F02-02 & -03
CNEXY	none	±1	---	F02-04 & -05
CNEXZ	none	±1	---	F02-06 & -07
CNEYX	none	±1	---	F02-17 & -18
CNEYY	none	±1	---	F02-19 & -20
CNEYZ	none	±1	---	F02-21 & -22
Longitude Correction	pirads	±1	East	F02-08 & -09
X Velocity Correction	fps	±3000 *	+X	F02-10
Y Velocity Correction	fps	±3000 *	+Y	F02-11
Z Velocity Correction	fps	±3000 *	+Z	F02-27
X Tilt Correction	arc sec	$\pm 2^{15}$ *	R.H WRT +X	F02-12
Y Tilt Correction	arc sec	$\pm 2^{15}$ *	R.H WRT +Y	F02-13
Z Tilt Correction	arc sec	$\pm 2^{15}$ *	R.H WRT +Z	F02-23

* See Note 2 of F02-30 in Format Section V of Appendix VI

Table I-1

INU Digital Signal Interface Inputs (continued)

SIGNAL	UNITS	REQUIRED RANGE	POSITIVE DIRECTION	REMARKS
X Gyro Bias Correction	rad/s	$\pm 2^{-13}$ *	R.H WRT +X	F02-14
Y Gyro Bias Correction	rad/s	$\pm 2^{-13}$ *	R.H WRT +Y	F02-15
Z Gyro Bias Correction	rad/s	$\pm 2^{-13}$ *	R.H WRT +Z	F02-16
X Accel Bias Correction	mg	±16.384	+X	F02-24
Y Accel Bias Correction	mg	±16.384	+Y	F02-25
Z Accel Bias Correction	mg	±16.384	+Z	F02-26
Baro-bias Correction	ft	±4096	Up	F02-28
Altitude Correction	ft	±4096	Up	F02-29
2nd Mode Word	---	---	---	F02-30
CC/INU Mode Word	---	---	---	F12/F17-01
Steering Error	pirads	±1	Right Steering Command	F17-02
Steerpoint (0-9)				
Coordinates Latitude	pirads	±1	North	F16- & F12-
Longitude	pirads	±1	East	F16- & F12-
Markpoint (1-3)				
Coordinates Latitude	pirads	±1	North	F12-
Longitude	pirads	±1	East	F12-
CADC Mode Word	---	---	---	C01/C02/ C03-01
Pressure Altitude	feet	±81920	Up	C01/C02/ C03-02
True Airspeed	knots	±2048	Forward	C01/C02/ C03-04

Notes: CC (Central Computer)
BCD (Binary Coded Decimal)
Refresh and Transmission rates are contained in Tables VI-2, VI-2a, VI-2b and the data word format section of Table VI-8.

* See Note 2 of F02-30 in Format Section V of Appendix VI.

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APPENDIX II

INU OUTPUT SIGNAL INTERFACES

(SERIAL DIGITAL)

Table II-1

INU Digital Signal Interface Outputs

SIGNAL	UNITS	REQUIRED RANGE	POSITIVE DIRECTION	REMARKS
INU Mode Word	---	---	---	I06/I08-01
Time Tag	µsec	---	---	I06/I08-02 (LSB=64µsec) I01/I05-02 I09-02
Velocity X	fps	±3000	+X	I06/I08-03 & -04 * I01/I05-03 & -04 * IH1-08 & -09 * I09-03 & -04 *
Velocity Y	fps	±3000	+Y	I06/I08-05 & -06 * I01/I05-05 & -06 * IH1-10 & -11 * I09-05 & -06 *
Velocity Z	fps	±3000	+Z	I06/I08-07 & -08 * I01/I05-07 & -08 * IH1-12 & -13 * I09-05 & -06 *
Platform Azimuth	pirads	±1	CW WRT X Axis	I06/I08-09 * I01/I05-09 * IH1-07 * I09-09 *
Roll	pirads	±1	Right Bank	I06/I08-10 * I01/I05-10 * IH1-02 * I09-10 *
Pitch	pirads	±1	Nose Up	I06/I08-11 * I01/I05-11 * IH1-01 * I09-11 *
True Heading	pirads	±1	CW WRT True North	I06/I08-12 * I01/I05-12 * IH1-03 *
Present Magnetic Hdg	pirads	±1	CW WRT Mag North	I06/I08-13 * I01/I05-13 *
Great Circle Steering Error	pirads	±1	CW WRT True Track	I06/I08-14 I01-26
Computed Course Deviation	pirads	±1	CW WRT Selected Course	I06/I08-15
Time To STR-PT	seconds	0 - 65536	---	I06/I08-16

Table II-1

INU Digital Signal Interface Outputs (continued)

SIGNAL	UNITS	REQUIRED RANGE	POSITIVE DIRECTION	REMARKS
Distance to STR-PT	nmi	0 - 6553	---	I06/I08-17
Relative Bearing to STR-PT	pirads	±1	CW WRT True Heading	I06/I08-18
Relative Bearing to nth WP/MP	pirads	±1	CW WRT True Heading	I06/I08-19
Time to nth WP/MP	seconds	0 - 65536	---	I06/I08-20
Distance to nth WP/MP	nmi	0 - 6553	---	I06/I08-21
INU Control Word 3	---	---	---	I06/I08-22
nth WP/MP Latitude	pirads	±1	North	I06/I08-23 & -24
nth WP/MP Longitude	pirads	±1	East	I06/I08-25 & -26
Magnetic Heading to Selected Steerpoint	pirads	±1	CW WRT Mag North	I06/I08-27
Selected Mag Course	pirads	±1	CW WRT Mag North	I06/I08-28
Magnetic Heading to Selected nth WP/MP	pirads	±1	CW WRT Mag North	I06/I08-29
True Air Speed	knots	±4096	Forward	I06/I08-30
Present Magnetic Ground Track	pirads	±1	CW WRT Magnetic North	I06/I08-31
Drift Angle	pirads	±1	Right Drift WRT Aircraft Centerline	I06/I08-32
UTM Coordinates	(Same as UTM inputs)			I07-01 to -14
Entered True Heading	pirads	±1	CW WRT True North	I07-15

Table II-1

INU Digital Signal Interface Outputs (continued)

SIGNAL	UNITS	REQUIRED RANGE	POSITIVE DIRECTION	REMARKS
Entered Magnetic Heading	pirads	±1	CW WRT Magnetic North	I07-16
Entered Magnetic Variation	pirads	±1	CW WRT Magnetic North	I07-17
Computed Magnetic Variation	pirads	±1	CW WRT True North	I07-18
Align Status	---	---	---	I07-19 bits 1 thru 6
Align Time	seconds	0 - 6138	---	I07-19 bits 7 thru 16
Wind Direction	pirads	±1	CW WRT True North	I07-20
Wind Velocity	knots	0 - 511	---	I07-21 bits 1 thru 13
Last MP Code	---	---	---	I07-21 bits 14 thru16
Ground Speed	knots	0 - 4095	---	I07-22
Present True Ground Track	pirads	±1	CW WRT True North	I07-23
Predicted Ground Speed	knots	0 - 4095	---	I07-24
Present Convergence Factor in Use	---	0 - 1.0000	---	I07-25
Present Grid Heading	pirads	±1	CW WRT Grid North	I07-26
Desired Grid Heading	pirads	±1	CW WRT Grid North	I07-27
Position Difference North	nmi	±327.67	North	I07-28
Position Difference East	nmi	±327.67	East	I07-29
INU Mode Word	---	---	---	I01/I05-01
Acceleration X	fps2	±512	+X	I01-14 *
Acceleration Y	fps2	±512	+Y	I01-15 *
Acceleration Z	fps2	±512	+Z	I01-16 *

Table II-1

INU Digital Signal Interface Outputs (continued)

SIGNAL	UNITS	REQUIRED RANGE	POSITIVE DIRECTION	REMARKS
CNEXX	none	±1	---	I01-17 & -18 I10-05 & -06
CNEXY	none	±1	---	I01-19 & -20 I10-07 & -08
CNEXZ	none	±1	---	I01-21 & -22 I10-09 & -10
Longitude	pirads	±1	East	I01-23 & -24
Inertial Altitude	ft	-1060 to +80337.5	Up	I01-25 * (see paragraph 3.2.1.5)
X Axis Residual Tilt	arc sec	±32,767	+X	I01-27 I10-02
Y Axis Residual Tilt	arc sec	±32,767	+Y	I01-28 I10-03
Mode Word II	---	---	---	I01-29
Roll Rate	pirad/s	±4	Right Bank	I01-30 * I09-12 *
Pitch Rate	pirad/s	±4	Nose Up	I01-31 * I09-13 *
Yaw Rate	pirad/s	±4	-Z	I01-32 * I09-14 *
Velocity North	fps	±3000	North	IH1-04 *
Velocity East	fps	±3000	East	IH1-05 *
Vertical Velocity	fps	±3000	Up	IH1-06 *
Velocity Time Tag	μsec	---	---	IH1-14
Platform Azimuth Time Tag	μsec	---	---	IH1-15 I09-18
Roll Time Tag	μsec	---	---	IH1-16 I09-19
Pitch Time Tag	μsec	---	---	IH1-17 I09-20
INU Mode Word	---	---	---	I09-01

Table II-1

INU Digital Signal Interface Outputs (continued)

SIGNAL	UNITS	REQUIRED RANGE	POSITIVE DIRECTION	REMARKS
Longitudinal Acceleration	fps2	±1024	Forward	I09-15 *
Lateral Acceleration	fps2	±1024	Right	I09-16 *
Normal Acceleration	fps2	±1024	Up	I09-17 *
Roll Axis Angular Acceleration	pirad/s2	±4	Right Bank	I09-21 *
Pitch Axis Angular Acceleration	pirad/s2	±4	Nose Up	I09-22 *
Yaw Axis Angular Acceleration	pirad/s2	±4	-Z	I09-23 *
Time Tag	μsec	---	---	I10-01
Z Axis Residual Tilt	arc sec	±32,767	+Z	I10-04
CNEYX	none	±1	---	I10-11 & -12
CNEYY	none	±1	---	I10-13 & -14
CNEYZ	none	±1	---	I10-15 & -16
CSNXX	none	±1	---	I10-17
CSNXY	none	±1	---	I10-18
CSNXZ	none	±1	---	I10-19
CSNYX	none	±1	---	I10-20
CSNYY	none	±1	---	I10-21
CSNYZ	none	±1	---	I10-22
Altitude Feedback Constant	1/sec	±6	---	I10-23 & -24
Velocity Feedback Constant	1/sec2	±6	---	I10-25 & -26
Acceleration Feedback Constant	1/sec3	±6	---	I10-27 & -28

Table II-1

INU Digital Signal Interface Outputs (continued)

SIGNAL	UNITS	REQUIRED RANGE	POSITIVE DIRECTION	REMARKS
Initialization Vectors				I11, I12, I13
Subsystem Status				I14

* See Table I for Jitter and Accuracy requirements

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APPENDIX III

ANALOG/DISCRETE SIGNAL INTERFACE

Table III-1

Analog/Discrete Inputs

SIGNAL	UNITS/REQUIRED RANGE	POSITIVE SENSE	REMARKS
INU TURN_ON	Continuity or open on J-131 pins 8 and 28	Cont = INU ON	Discrete (Note 1)
BUS CONTROL	Logic 1 = +2 volts min diff P-131 pin 51 = +2.4V to +5.5V pin 17 = 0.0V to +0.4V Logic 0 = -2 volts min diff P-131 pin 51 = 0.0V to +0.4V pin 17 = +2.4V to +5.5V P-131 pin 51 } pin 17 } See Note 3 P-131 pin 51 } pin 17 }	INU RT INU Backup Controller INU Backup Controller INU Backup Controller	Complementary Differential (driver powered down)
MUX TERMINAL ADDRESS ID CODE INPUT	Continuity from P-132 pin 26: to P-132 pin 34 = 16 to P-132 pin 35 = 8 to P-132 pin 36 = 4 to P-132 pin 37 = 2 to P-132 pin 38 = 1	Continuity = Value Selected	Add selected pin values to determine MUX terminal address
ATTITUDE MODE	28 volts DC or Open	28V = ATTD MODE	Discrete-INU load>10KΩ
SELECTED COURSE	Zero to 359.9 Degrees	CW WRT Magnetic North	3 Wire Synchro (Note 2)
DESIGNATE	28 volts DC or Open	28V = DESIGNATE	Discrete

Note 1: Turn-off via Mux Bus or by the absence of the INU "on" discrete.

Note 2: This input may be from one CDSH-10-AS-4, or equivalent, 3 wire synchro or from two CDSH-10-AS-4 synchros connected in parallel. Only one synchro will transmit at a time. Synchro high null electrical zero shall be at zero degrees for the North selected course.

Note 3: There are four possible conditions:
(a) Actively driven with Pin 51 high and 17 low
(b) Actively driven with Pin 51 low and 17 high
(c) Both inputs open (or high)
(d) both inputs to ground through an unpowered complimentary output TTL driver

The INU will not operate as a bus controller if Pin 51 is high and Pin 17 is low. (See Paragraph 60.4 & 60.4.4.1) The integrator is cautioned that if a TTL device is directly connected the "off state" impedance shall be greater than 22KΩ.

Table III-2

Dual Analog Outputs (See Note 3)

SIGNAL	RANGE/POSITIVE SENSE	ACCURACY	REMARKS
ROLL (Note 1) 50 Hz Minimum Refresh Rate	0 to 359.9 degrees/ Right Bank	0.067 degree (RMS)	Synchro Buffered (X & Y legs buffered, Z leg grounded at the buffer output within the INU)
PITCH (Note 1) 50 Hz Minimum Refresh Rate	0 to 359.9 degrees/ Nose Up	0.067 degree (RMS)	Synchro Buffered (X & Y legs buffered, Z leg grounded at the buffer output within the INU)
COMPUTED (Note 2) COURSE DEVIATION 12.5 Hz Minimum Refresh Rate	±10 degrees (±150 μAMP) per Bar to Right	±10 μAMP	Analog (DC); 1000Ω minimum load to each output

Note 1: Each output shall be from separately driven buffers and be capable of driving a total Zso of (47 + j74)Ω with less than 10% reduction in open circuit voltage output. Phase shift shall be plus 14 ± 4 degrees lead. The synchro output signals must interface with equipment utilizing either high or low null. Selection must be made external to the INU. The roll and pitch synchro output high null electrical zero shall be at zero degrees roll and pitch indication when pin 25 on J-132 is open (not grounded). With pin 25 on J-132 grounded, zero roll and pitch indication shall be provided at 180 degrees roll and pitch synchro output angles. When grounded, pin 25 shall be tied to pin 27.

Note 2: This output shall be synchronized with the TO/FROM output to simulate operation similar to a TACAN or VOR operation, i.e. ABS(Great Circle Bearing - Selected Course) < 90 degrees results in a TO indication; a FROM indication results whenever ABS(Great Circle Bearing - Selected Course) ≥ 90 degrees.

Note 3: A failure detected at these outputs shall not indicate an INU failure.

Table III-3

Single Analog Discrete Outputs (See Note 3)

SIGNAL	RANGE/POSITIVE SENSE	ACCURACY	REMARKS
COMPUTED RANGE TO STEERPOINT (Note 1) 1.5625 Hz min Refresh Rate	0-999/Range Increase	0.5 nmi (RMS)	Two sets of three each HSI synchro loads with a total load Zso of (5 + j22.5)Ω with less than 10 percent reduction in open circuit voltage amplitude; 10 ± 6 degrees lead phase shift.
COMPUTED STR-PT RELATIVE BRG (Note 1) 12.5 Hz Refresh Rate	0-359.9 degrees/ Clockwise Increasing Course	±0.5 deg (MAX)	Two HSI CTH-8-A-6 synchro loads, with a total load Zso of (60+j225)Ω with less than 10 percent reduction in open circuit voltage amplitude; ± 1 degree phase shift.
MAG HEADING (PLATFORM AZ IN ATT MODE) (Note 1) 50 Hz Refresh Rate	0-359.9 degrees/ Increasing Heading WRT Magnetic North	0.3 degree (RMS)	Two HSI and TACAN synchro loads with a total load Zso of (47 + j74)Ω with less than 10 percent reduction in open circuit voltage amplitude;+14 ± 4 degrees lead phase shift.
TO/FROM (Note 2)	0 ± 30 μAMPS = No Flag; +325 ± 100 μAMPS = TO -325 ± 100 μAMPS = FROM	-	This discrete shall be capable of driving two HSI TO/FROM flags with a combined load of 100Ω (200Ω each) ± 15%.
ATTITUDE GOOD	Open or Aircraft 28 VDC (28 VDC = True)	-	This discrete shall be capable of driving two ADI flags with a combined load of 750Ω minimum (1500Ω each) or one each MIL-R-3901616-XXX 26.5 VDC coil, 700Ω ±10% coil resistance
MAG HEADING GOOD	Open or Aircraft 28 VDC (28 VDC = True)	-	This discrete shall be capable of driving one 720Ω ± 10% load.
MAG HEADING BAD	Open or Aircraft 28 VDC (28 VDC = True)	-	This discrete shall be capable of driving one 720Ω ± 10% load.

Note 1: Null requirements for outputs to HSIs are as follows:

a. Computed Range to Steerpoint Outputs. High null electrical zero shall be at zero degrees for a zero range indication. Increasing synchro output angle to 36 degrees shall result in a "1" being displayed on the HSI range readout for each synchro. Increasing numerical range readings shall be indicated for each 36 degrees increase in each synchro output.

b. Computed Steerpoint Relative Bearing Output. High null electrical zero shall be a synchro output angle of 180 degrees.

c. Magnetic Heading Output. High null electrical zero shall correspond to a synchro angle of zero degrees at the North heading.

Note 2: TO/FROM indications shall be consistent with the operation expected when being driven by a TACAN or VOR and shall be synchronized with the Computed Course Deviation output, i.e. ABS(Great Circle Bearing - Selected Course) < 90 degrees results in a TO indication; whenever ABS(Great Circle Bearing - Selected Course) ≥ 90 degrees, the result is a FROM indication.

Note 3: A failure detected at these outputs shall not indicate an INU failure.

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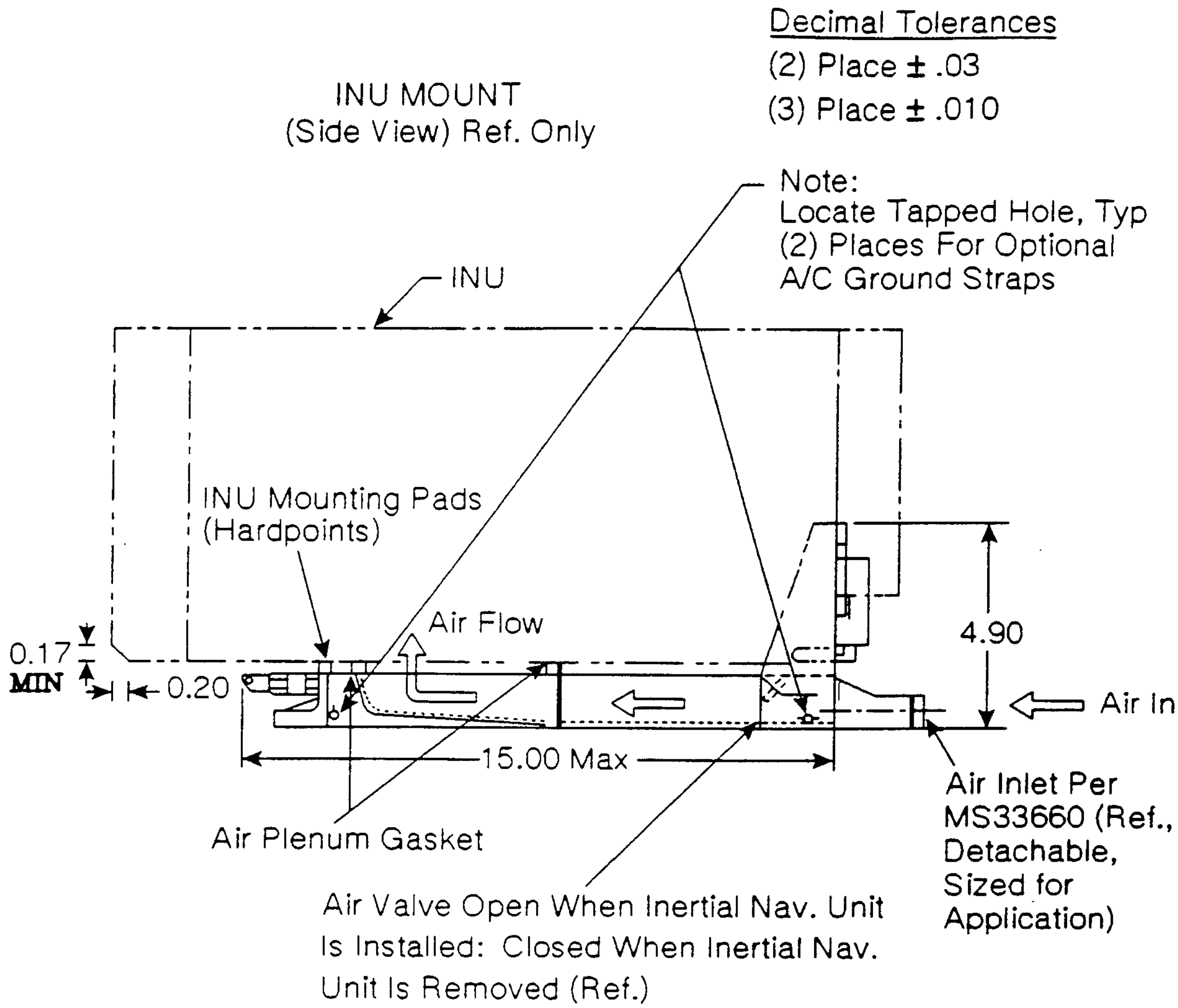
APPENDIX IV

INU OUTLINE AND MOUNTING DRAWINGS



NOTE: A potential for accidental cable reversal exists on the integrator side of the INU mount. Precautions must be taken by the integrator to insure that accidental cable reversal does not cause damage to the INU during installation/integration or attachment to test equipment.

Figure IV-1
INU Mount (Side View)

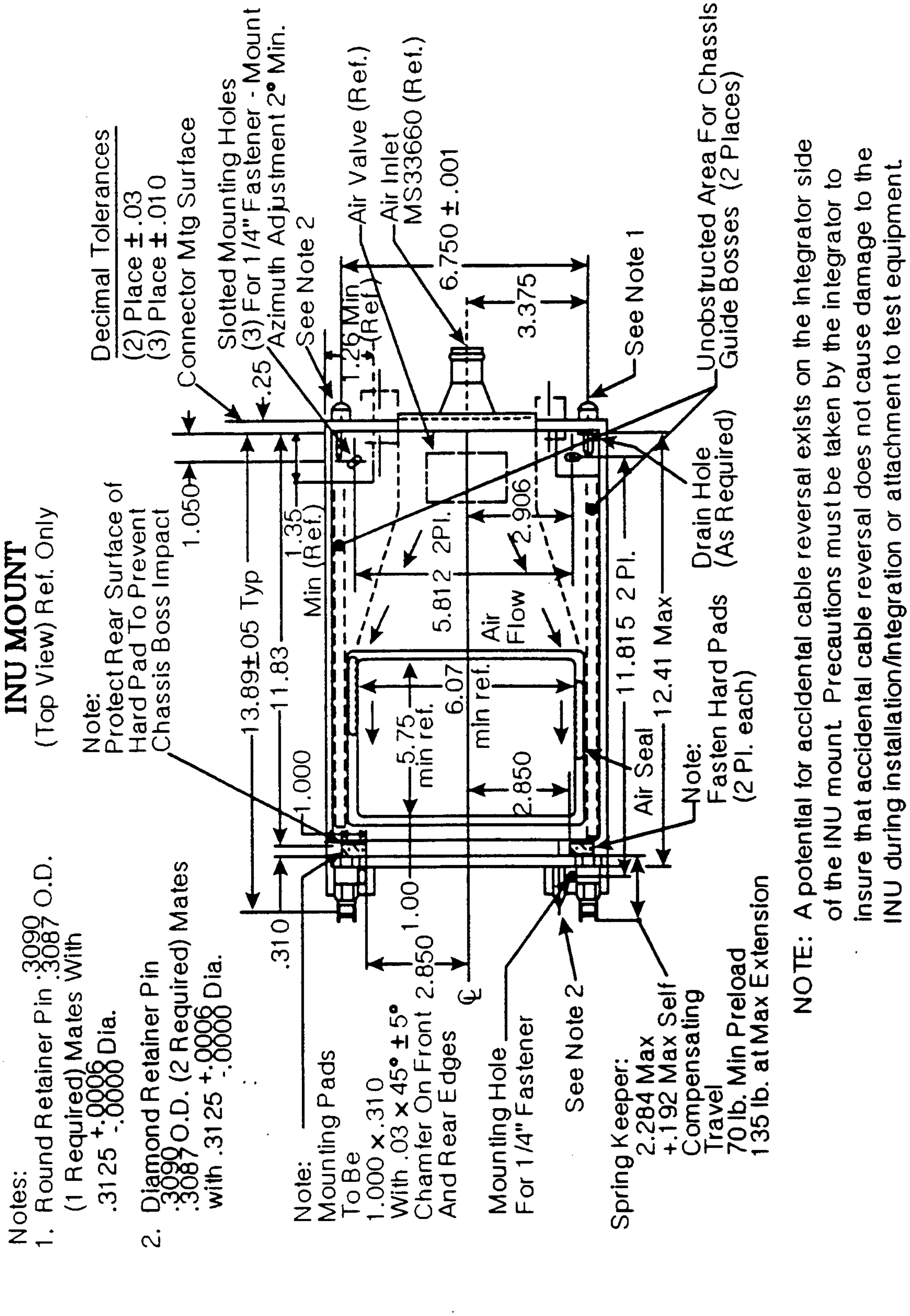
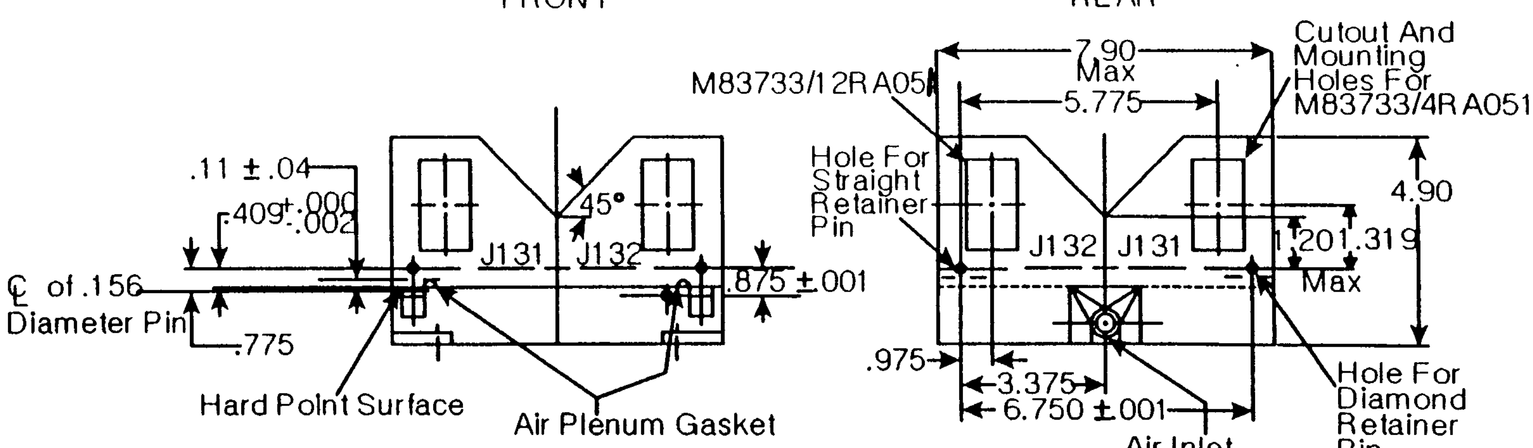


Figure IV-2
INU Mount (Top View)

F-16 Type Battery
Mating connector
MS27467T11F35S
(Backshell → MS27506F10-2)
(Strain relief)

INU MOUNT
(End Views) Ref. Only

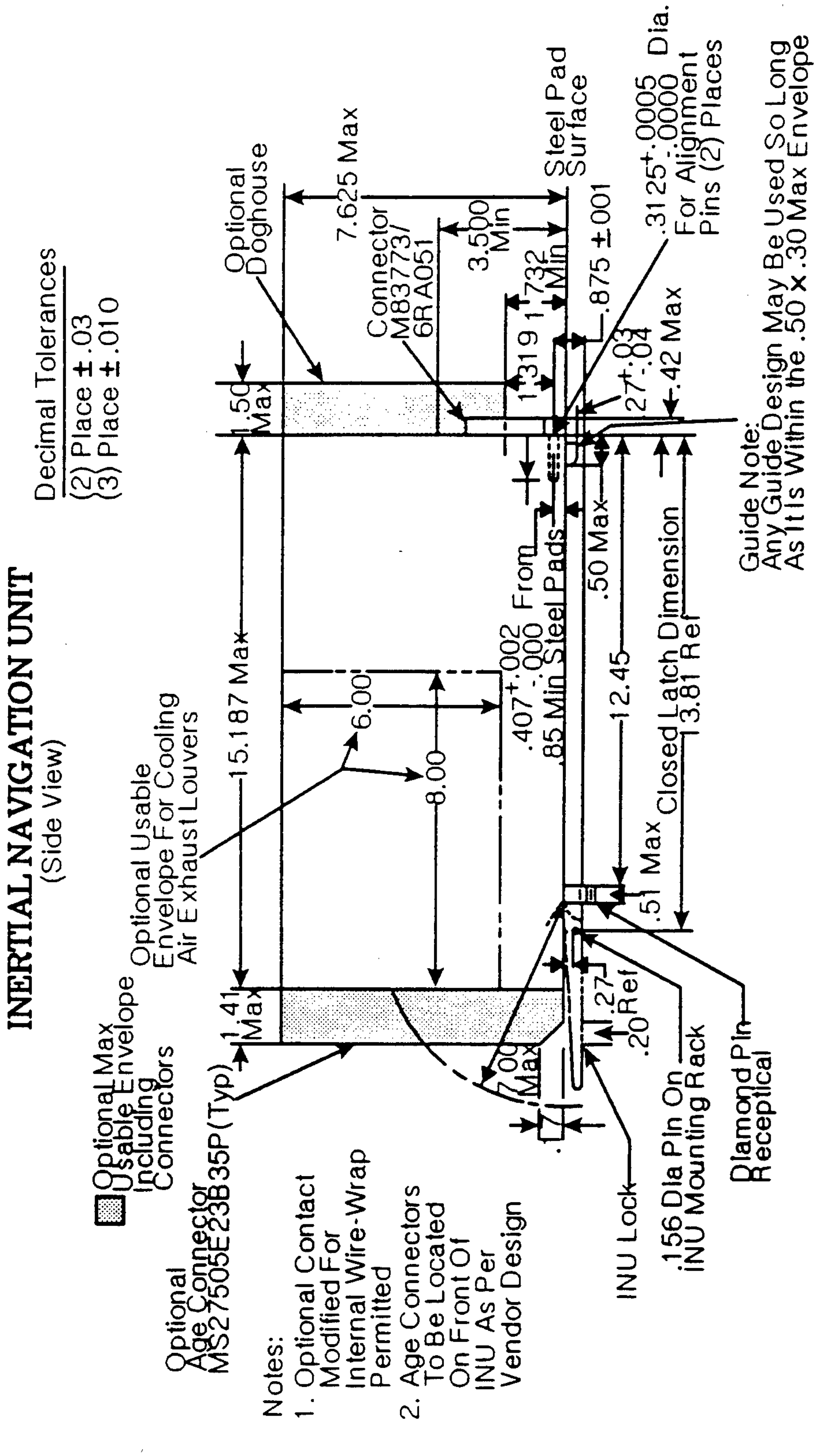
Decimal Tolerances
(2) Place ±.03
(3) Place ±.010



Note: Surface Of Rails Alongside Air Gasket Shall Be No Higher Than Hard Point Surface And No Lower Than .10 Below Hard Point Surface

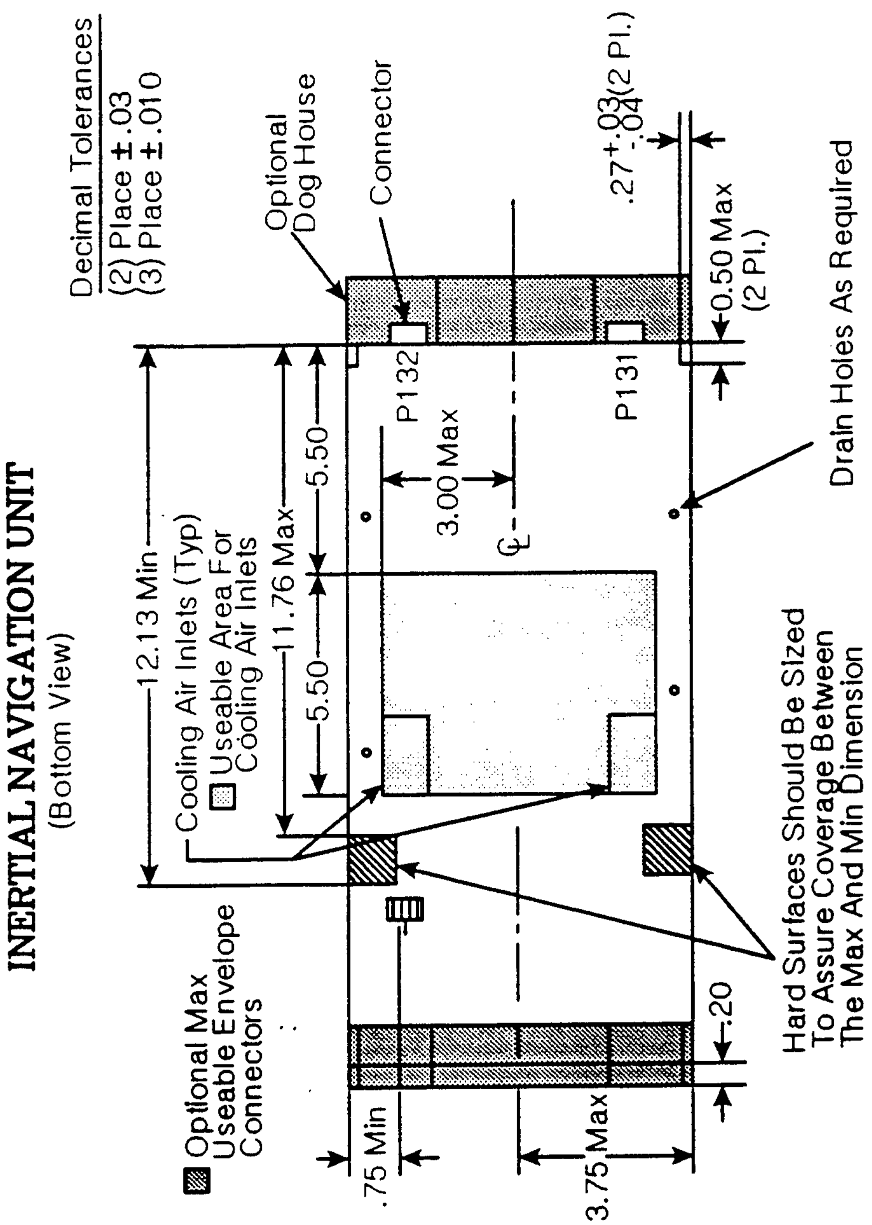
NOTE: A potential for accidental cable reversal exists on the integrator side of the INU mount. Precautions must be taken by the integrator to insure that accidental cable reversal does not cause damage to the INU during installation/integration or attachment to test equipment.

Figure IV-3
INU Mount (End Views)



NOTE: A potential for accidental cable reversal exists on the integrator side of the INU mount. Precautions must be taken by the integrator to insure that accidental cable reversal does not cause damage to the INU during installation/integration or attachment to test equipment.

Figure IV-4
Inertial Navigation Unit (Side View)



NOTE: A potential for accidental cable reversal exists on the integrator side of the INU mount. Precautions must be taken by the integrator to insure that accidental cable reversal does not cause damage to the INU during installation/integration or attachment to test equipment.

Figure IV-5
Inertial Navigation Unit (Bottom View)

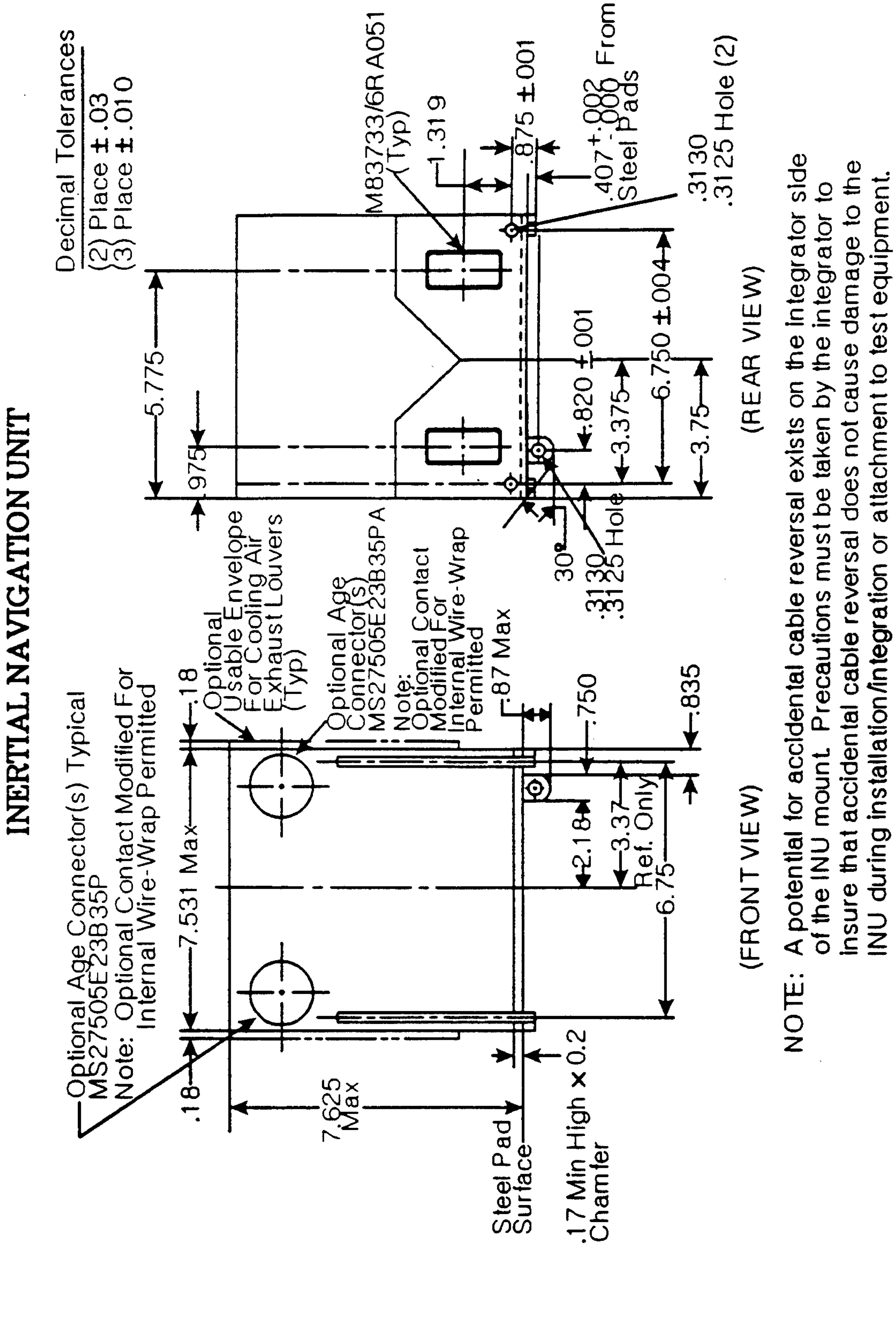


Figure IV-6
Inertial Navigation Unit (End View)

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APPENDIX V

MOUNTING ORIENTATION AND SOFTWARE BORESIGHTING

50. MOUNTING ORIENTATION AND SOFTWARE BORESIGHTING

50.1 Introduction

The purpose of this section is to provide the ability to mount the INU in any orientation in the aircraft and/or to allow software boresighting of the INU to the aircraft to compensate for known mechanical misalignment of the INU mounting rack assembly relative to the aircraft axes.

50.1.1 Expected Use

The orient function is defined as an operational mode. It is expected that entry and control of this mode shall be implemented by the weapon system integrator as an automatic part of the overall system initialization process.

Except for maintenance actions after a system component change, the orient mode shall not be made routinely available to operators. Caution should be exercised in system integration to ensure this mode will not be entered at inappropriate times.

50.2 Reference Frame and Axis Definitions

The orientation of the INU shall be referenced to aircraft body roll, pitch, and yaw axes (X_b, Y_b, and Z_b). The INU mount and INU chassis axes are assumed to be coincident. The orthogonal axes referenced to the INU chassis (X_r, Y_r, and Z_r) shall be with respect to the center of the precision diamond mounting alignment pin as it emerges from the INU mount and are defined for the default orientation as shown in Figure 13.

a. The inertial instruments are assumed to be rotated/translated to the INU chassis (X_r, Y_r, and Z_r). The INU manufacturer shall include internal provisions for establishing the inertial instrument axes with respect to the INU chassis axes; however, such provision shall be separate from and transparent to corrections for orientation/boresighting.

b. The location and orientation of the instruments within the chassis relative to the precision diamond mounting pin shall be made available in I13-07 through I13-15.

50.2.1 Order of Rotation

The processing of orientation and boresight angle data shall be in roll, pitch, and yaw order. Note that this requirement does not constrain the order in which angle data is entered into the INU. A positive rotation shall be a clockwise rotation from the body frame to INU chassis frame (see Section 6.4 and 6.5). Specifically, pitch up is positive; right wing down is positive; yawing clockwise is positive.

50.3 Orientation Term Definitions

The terms "basic" and "total" orientation will be used throughout this section. Basic orientation refers to orientations achieved by orthogonal (90 degrees) rotations of the INU chassis about the aircraft body axes (X_b, Y_b, and Z_b) without additional rotations as a result of boresight corrections. Total orientation is defined as the sum of any basic orientation and any boresight correction (see section 50.6) that the INU must apply to its outputs. Note that total orientation as defined also includes any correction applied by the manufacturer to establish the inertial instrument axes with respect to the INU chassis axes.

50.4 Bit Field Numbering Convention

Throughout this section, binary patterns are presented which represent data bits appearing in fields within 16-bit words. Data bits or fields are referenced by bit numbers which represent bit locations as follows:

Bit Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Binary Data	0	0	0	0	1	0	1	0	1	1	1	0	1	0	1	0
	MSB *	*	*	*	*	*	*	*	*	*	*	*	*	*	*	* LSB

For example, the binary pattern for a field containing bits 13-16 would be shown as 1010. Likewise, the binary pattern for bits 3-5 is 001. Note that bit 1 is the first to be transmitted in a serial bit stream.

50.5 Orientations

50.5.1 General

Provision is made to allow the INU to operate in multiple orthogonal orientations in the aircraft. The operating orientation shall be programmed over the data bus.

50.5.2 Basic Orientation Range

The basic orientations are 0, 90, 180, and 270 degrees about each of the aircraft body roll, pitch, and yaw axes (X_b, Y_b, and Z_b) individually or in combination. The INU shall accept programming commands for the entire range of basic orientations regardless of the INU's ability to operate in the commanded orientation. If an optional orientation as defined in Table V-1 is selected, the INU shall set appropriate out-of-range flag bit(s) in the Orient Status Word and INU mode/control words.

50.5.3 Performance

Within the required operating capability, the INU shall provide specified performance when mounted in any basic orientation in the aircraft. The INU shall be able to accommodate commanded orientations and/or boresight angles without internal mechanical adjustment to or repositioning of the sensor assembly. All INU attitude, velocity, and acceleration data shall be corrected internally to compensate for INU orientation so that the data will be correct for the aircraft body axes (X_b, Y_b, and Z_b). All data output from the INU shall be the correct values for the aircraft body axes after corrections are applied.

50.5.4 Required Operating Capability

The required operating capability shall comply with the values shown in Table V-1.

Table V-1. Required Basic Orientation Capability

Roll (X_r)	0, 90*, 180*, 270* degrees
Pitch (Y_r)	0, 90*, 180*, 270* degrees
Yaw (Z_r)	0, 90, 180, 270 degrees

* optional: The INU is not required to meet the performance requirements defined in Table I.

50.5.5 Orientation Programming

Command to assume any basic orthogonal orientation may be accomplished via data bus software command. The orientation of the INU relative to the aircraft body axes shall be programmable by data bus software command.

The INU shall ignore any Orient/Boresight command which is defined to be a prohibited, illegal, or reserved function command. Bit 14 (Illegal Command) of I06/I08-22 shall be set in response to such a command.

50.5.5.1 Default Basic Orientation

Upon application of power, the orient function shall be disabled and the INU shall assume the default basic orientation. The default basic orientation shall remain in effect until overridden by command of Orient mode via D01-01 function select and subsequent appropriate command and data insert via D01-02 and D01-03.

50.5.5.2 Non-default Orientations Operation

Operation of the INU in any orientation other than the default orientation shall require programming via the data bus. Entry of orientation commands and data shall be possible only when the INU is in the Orient mode.

50.5.5.2.1 Orient Mode

The purpose of the Orient mode is to prevent inadvertent programming of orientations or boresight angles into the INU while in normal operation. Any attempt to enter orientation/boresighting commands or data when the INU is not in the Orient mode shall invoke an illegal command error.

a. The Orient mode may only be entered from the STANDBY mode. Entry into the ORIENT mode shall be commanded via D01-01 CDU Control Word 1 Function Select Code 01101 (ORIENT).

b. When the INU is in the ORIENT mode, orientation and boresight command programming and angle data programming shall be by the D01-02 CDU Control Word 2 commanding ORIENT Command/Data Insert. The ORIENT Command/ Data Insert code for D01-02 bits 6-10 shall be 01100 (Orient Command/Data Insert).

c. Following selection of Orient mode via D01-01 and command of ORIENT Command/Data Insert via D01-02, the actual orientation and boresight functions to be initiated must be specified via the Orient Control Word (D01-03). The structure of the Orient Control Word D01-03 is shown in Appendix VI Section I Format XIII.

50.5.5.2.2 Non-default Orientation Command

In order to operate the INU in a non-default orientation, the INU must be commanded to the Orient mode via both D01-01 Orient function select and D01-02 Orient command and data insert. Data bits 1 and 2 of the Orient Control Word (D01-03) determine whether the orient function is enabled.

a. Data bit 1 set to logic 1 shall enable the orient function. When the orient function is enabled, the INU shall assume the basic orthogonal orientation which is specified by basic orientation data bits stored in the Orient Status Word. The stored basic orientation must have been previously specified for each axis and shall override the default orientation assumed during power-up when the orient function is enabled.

b. Data bit 1 set to logic 0 shall disable the orient function. In this condition, the INU shall assume the default orientation. The stored values for basic orientation shall not be used to correct INU outputs.

50.5.6 Basic Orientation Storage

The basic orientation shall be stored in bits 3-8 of the Orient Status Word (Miscellaneous Parameter 36). The basic orientation for each axis shall be encoded as unsigned two-bit binary values. Miscellaneous Parameter 36 shall be non-volatile; however, it shall be set to all zeros upon power-up. Therefore, any non-default orientation must be programmed during the INU initialization sequence following any shutdown.

50.5.6.1 Software Basic Orientation Entry

Basic orientation shall be entered into the Orient Status Word (Miscellaneous Parameter 36) according to the method specified by the binary pattern of data bits 3, 4, and 5 of the Orient Control Word D01-03. Directly storing data via Miscellaneous Parameter Insert to Miscellaneous Parameter 36 shall not be permitted; and any attempt to do so shall invoke an "illegal command" error. The functions of bits 3, 4, and 5 of D01-03 are described below.

a. Binary pattern 000 shall command that no basic orientation is to be entered. Values previously stored in the Orient Status Word shall remain unaltered.

b. Binary pattern 001 shall command comparison or reprogramming of basic orientation data stored in the Orient Status Word according to the the option selected by data bit 6 of the Orient Control Word.

   1. If data bit 6 of Orient Control Word specifies Compare Entered Data (Bit 6 set to 0), data from subsequent word D01-04 shall be compared to corresponding values stored in the Orient Status Word. The results of the comparison shall be reflected in the Orient Status Word Entered Data Compare bit (bit 9). The stored values shall remain unaltered.

   2. If data bit 6 of the Orient Control Word specifies Store Entered Data (Bit 6 set to 1), data from subsequent word D01-04 shall overwrite previously stored data in the appropriate bits of the Orient Status Word.

c. Deleted.

d. Binary pattern 101 shall command that all basic orientation bits stored in the Orient Status Word shall be set to zero.

50.5.6.1.1 Software Basic Orientation Entry Format

When the Orient Control Word D01-03 specifies data bus entry of basic orientation (bits 3, 4 and 5 of D01-03 set to binary 001), bits in subsequent data word D01-04 shall represent unsigned 2-bit values encoded to represent basic orthogonal orientations in each of the roll (Xr), pitch (Yr), and yaw (Zr) axes. The format for the basic orientation data word is shown in Appendix VI, Section I Format XIII.

50.5.6.1.2 Deleted

50.5.6.2 Basic Orientation Readout

Stored basic orientation shall be readable from the INU via I13-17 or a Miscellaneous Parameter Read of Miscellaneous Parameter storage location 36 (Orient Status Word). The format of the data presented shall depend upon the method used.

a. Readout of the basic orientation via Miscellaneous Parameter Read of data stored in Miscellaneous Parameter 36 shall comply with the Miscellaneous Parameter Read format (Format IX) described in Appendix VI. The ASCII characters presented shall display the basic orientation as described in Table V-3.

b. Readout of I13-17 shall present the Orient Status Word and shall comply with the format shown for the Orient Status Word shown in section 50.7. Within I13-17, data bits 3-8 shall present the basic orientation data.

50.6 Boresighting

50.6.1 General

Boresighting the INU in the aircraft may be accomplished by the traditional mechanical methods, by software, or by a combination of both. Provision is made to allow software boresight corrections to be entered over the data bus.

50.6.2 Boresight Range

The software boresight correction angle range shall be ± 45 degrees in each of the INU roll, pitch, and yaw axes (X_r, Y_r, and Z_r) individually or in combination. Software boresight corrections may be applied to any basic orientation, thus allowing operation in any total orientation in the aircraft. The INU shall accept programming commands for the entire range of boresight corrections regardless of the INU's ability to operate using the correction programmed or to operate in the total orientation resulting from application of the correction. If a commanded boresight correction exceeds the values in Table V-2, the INU shall set appropriate out-of-range and/or degraded performance flag bit(s) in the Orient Status Word and INU mode/control words. Entry of any boresight angles greater than ± 45 degrees shall be rejected and cause setting of the illegal command bit (I06-22 bit 14).

50.6.3 Performance

Within the minimum required operating capability, the INU shall provide specified performance when commanded to use any specified boresight correction value applied to any basic orientation which the INU is required to accommodate in Table V-1. The INU shall accommodate commanded boresight corrections without internal mechanical adjustment to or repositioning of the sensor assembly. All INU attitude, velocity, and acceleration data shall be corrected internally to compensate for total orientation so that the data will be correct for the aircraft body axes (X_b, Y_b, and Z_b). All data output from the INU shall be the correct values after corrections are applied.

50.6.4 Required Operating Capability

The required operating capability shall comply with the values shown in Table V-2 below.

Table V-2 - Required Boresight Correction About Any Basic Orientation

Roll (X_r)	± 3 degrees
Pitch (Y_r)	± 3 degrees
Yaw (Z_r)	± 3 degrees

50.6.5 Boresight Programming

Command to apply boresight corrections shall be accomplished via data bus software command. The boresight correction angles applied to the INU outputs shall be programmable via data bus software command.

50.6.5.1 Default Boresight Operation

Upon application of power, the INU shall assume the default condition of boresight correction. Stored boresight correction angles shall remain unaltered but shall not be used for correction of INU data output unless specifically commanded to do so by appropriate software commands. The default condition shall remain in effect until overridden by command of Orient mode via D01-01 function select and subsequent appropriate command and data insert via D01-02 and D01-03.

50.6.5.2 Non-default Boresight Operation

Because boresighting is an extension of the Orient mode, the INU must be commanded to the Orient mode via both D01-01 function select and D01-02 Orient command and data insert to enable and program boresight corrections. Boresight correction is enabled by setting data bits 1 and 2 of D01-03 to binary pattern 11 (Orient On/Boresight ON). INU operation involving boresight corrections shall require entry of a basic orientation even if it is a default orientation. The following specifies the order of operation:

a. At powerup, the boresight correction values previously stored in non-volatile memory shall be available in I13-18, -19, -20, and Miscelaneous Parameters 37, 38, and 39.

b. These outputs shall be overwritten when D01 boresight correction values are recieved.

c. If the boresight function is enabled, the values in I13-18, -19, and -20 and Miscellaneous Parameters 37, 38, and 39 shall be used to correct system output data.

d. The values in I13-18, -19, -20, and Miscellaneous 37, 38, and 39 shall be saved in the INU non-volatile memory at shutdown.

50.6.6 Boresight Correction Angle Storage

Boresight correction angles shall be stored as signed 16-bit binary values as described in Format XIII of Appendix VI.

50.6.6.1 Boresight Angle Entry

Boresight angles shall be entered into Miscellaneous Parameters 37, 38, and 39 according to the method specified by the binary pattern of data bits 3, 4, and 5 of the Orient Control Word D01-03. Directly storing data via Miscellaneous Parameter Insert to Miscellaneous Parameters 37, 38, and 39 shall not be permitted; and any attempt to do so shall invoke an "illegal command" error. The functions of bits 3, 4, and 5 of D01-03 are described below.

a. Binary pattern 000 shall command that no boresight data is to be entered. Values previously stored in Miscellaneous Parameters 37-39 shall remain unaltered.

b. Binary pattern 010 shall command comparison or reprogramming of boresight angles stored in Miscellaneous Parameters 37-39 according to the the option selected by data bit 6 of the Orient Control Word.

   1. If data bit 6 of Orient Control Word specifies Compare Entered Data (Bit 6 set to 0), data from subsequent words D01-04, D01-05, and D01-06 shall be compared to values stored in Miscellaneous Parameters 37, 38, and 39 respectively. The results of the comparison shall be reflected in the Orient Status Word Entered Data Compare bit (bit 9). The stored values shall remain unaltered.

   2. If data bit 6 of the Orient Control Word specifies Store Entered Data (Bit 6 set to 1), data from subsequent words D01-04, D01-05, and D01-06 shall overwrite previously stored data in Miscellaneous Parameters 37-39 respectively.

c. Deleted

50.6.6.1d

d. Binary pattern 110 shall command that the boresight correction angles stored in Miscellaneous Parameters 37-39 to be set to zero.

50.6.6.1.1 Software Boresight Angle Entry Format

When the Orient Control Word D01-03 specifies data bus entry of boresight angles (bits 3, 4 and 5 of D01-03 set to binary 010), subsequent data words D01-04, D01-05, and D01-06 shall represent signed 16-bit values in the range of 0 to ± 45 degrees for boresight correction to the INU chassis roll (X_r), pitch (Y_r), and yaw (Z_r) axes respectively. The format for these angle data words is shown in Format XIII in Appendix VI.

50.6.6.1.2 Deleted

50.6.6.2 Boresight Angle Readout

Stored boresight correction angles shall be readable from the INU via I13-18 through I13-20 or a Miscellaneous Parameter Read of Miscellaneous Parameter storage locations 37, 38, and 39. The format of the data presented shall depend upon the method used.

a. Readout of the boresight angles via Miscellaneous Parameter Read of angles stored in Miscellaneous Parameters 37, 38, and 39 shall comply with the Miscellaneous Parameter Read format (Format IX) described in Appendix VI. The ASCII characters presented shall display the boresight angle in the following manner: sDDMMSS where s represents the sign character (+ or -), DD represents 0 to 45 whole degrees, MM represents 0 to 59 arc minutes, and SS represents 0 to 59 arc seconds. If a boresight angle of greater than ±45 degrees is entered, the INU shall not accept the entered value and shall set the illegal command bit.

b. Readout of the boresight correction angles via I13-18 through I13-20 shall be a signed binary representation of the values stored and shall comply with the format shown for words D01-04 through D01-06 in Appendix VI. I13-18, I13-19, and I13-20 shall present values for roll, pitch, and yaw (X_r, Y_r, and Z_r) boresight corrections stored in Miscellaneous Parameter locations 37, 38, and 39 respectively.

50.7 Orient Status Word (Miscellaneous Parameter 36)

50.7.1 Description

The Orient Status Word shall reflect the on/off status of the orient and boresight functions, the selected basic orientation, entered data compare flag, and orientation and boresight range check flags. The structure of the Orient Status Word is shown in Table V-4.

50.7.1.1 Orient and Boresight On/Off Status

The ON/OFF status of the orient and boresight functions commanded via D01-03 shall be reflected in bits 1 and 2. The binary pattern 01 which represents an illegal command shall never occur.

50.7 .2 Stored Basic Orientation

The basic orientation (default or programmed) shall be reflected in data bits 3 through 8. When the Orient function is enabled, the basic orientation reflected shall always be that basic orientation which the INU is using to correct its data outputs. When the Orient function is disabled, the basic orientation reflected shall be the default orientation assumed at power-up or the last programmed basic orientation.

50.7.1.3 Entered Data Compare Flag

The value of the entered data compare flag (bit 9) shall reflect the result of a bit-wise comparison of entered data and the corresponding data stored within the INU whenever any commanded data entry function specifies the entry compare option. The flag shall remain in the state reflecting the result of the comparison until a subsequent entered data compare option command.

50.7.1.4 Boresight Data Store Complete Flag

The Boresight Data Store Complete Flag (bit 10) shall reflect the status of the process of storing boresight angle data via the data bus into appropriate bit locations in the 16-bit boresight angle Miscellaneous Parameter storage locations.

a. The flag shall be set to logic 1 upon receipt of a command to store data bus angle data and it shall remain set until successful storage of all boresight angles has been accomplished at which time it shall be reset to logic 0.

b. Deleted.

c. Enabling the boresight function shall not be permitted while the flag is set. An attempt to do so shall invoke an "illegal command" error.

d. The flag shall be reset by a command to clear all boresight angles, or successful storage of boresight angles via data bus entry.

50.7.1.5 Orient and Boresight Range Check Flags

The orient and boresight range check flags shall reflect the ability of the INU to operate using the basic orientation, boresight angles, and resulting total orientation which would be in effect if the stored orientation and boresight values were used. The values of the range check flags (bits 11, 12, and 13) shall reflect potential use of stored values regardless of whether orient or boresight functions (determined by bits 1 and 2) are on or off. See Table 50.7.1.5.

Table 50.7.1.5 Orient Out Of Range

	OUT OF RANGE CHECK FLAGS			
	BORESIGHT OUT ORIENT IN TOTAL OUT	BORESIGHT OUT ORIENT OUT TOTAL OUT	BORESIGHT IN ORIENT OUT TOTAL OUT	BORESIGHT IN ORIENT IN TOTAL IN
ORIENT ON BORESIGHT OFF		X X X X X X	X X X X X X	
ORIENT ON BORESIGHT ON	X X X X X X	X X X X X X	X X X X X X	
ORIENT OFF BORESIGHT OFF				

X - Nav performance may be affected

50.7.2 <u>Orient Status Word Storage</u>

The Orient Status Word shall be stored in Miscellaneous Parameter 36.

a. Miscellaneous Parameter 36 shall be non-volatile memory and shall be set to all zeros upon power-up. After power-up, appropriate bits within the Orient Word shall be set by the INU according to the results of internal calculations/operations and/or in response to Orient Control Word (D01-03) commands.

b. Miscellaneous Parameter 36 shall be read-only and writing directly to this location via Miscellaneous Parameter Insert shall not be permitted. An attempt to write directly to this location shall invoke an "illegal command" error.

50.7.3 <u>Status Readout</u>

The status of the INU orientation and boresight functions shall be able to be determined during any operational mode by performing either a Miscellaneous Parameter Read of Miscellaneous Parameter 36 or via I13-17. The format of the data presented shall depend upon the method used.

a. Readout of the Orient Status Word via Miscellaneous Parameter read of Miscellaneous Parameter 36 shall comply with the Miscellaneous Parameter Read format (Format IX) described in Appendix VI. The ASCII characters presented shall comply with Table V-3.

b. Readout of the Orient Status Word via I13-17 shall be a binary representation of the bits stored in Miscellaneous Parameter 36 and shall comply with the format shown in Table V-4.

50.8 Deleted

50.9 Software Orientation and Boresighting Examples

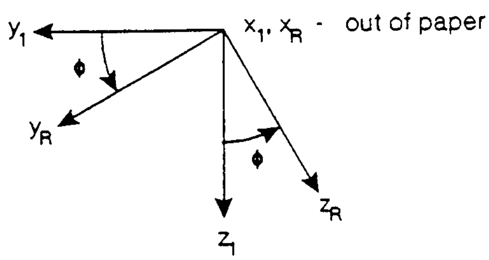
For software boresighting or orientation, the INU shall provide required transformations to convert INU outputs from the INU chassis frame (R) reference to the aircraft body frame (B). The following discussion is presented to illustrate the transformation process and sign conventions.

All frames shown are right-handed and all angles are positive as drawn.

ϕ = roll angle $c\phi$, $c\theta$, $c\psi$ = cosine of ϕ, θ, ψ
θ = pitch angle $s\phi$, $s\theta$, $s\psi$ = sine of ϕ, θ, ψ
ψ = yaw angle

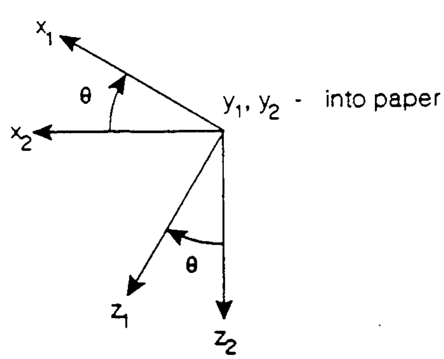
The following is the general case identifying the steps necessary to perform the transformation. In the example, the transformation is divided into steps a, b, and c. The transformation must be performed for both orientation and boresight.

a. The first transformation performed shall be from the "R" frame to an intermediate frame, identified as "1", through roll as follows:



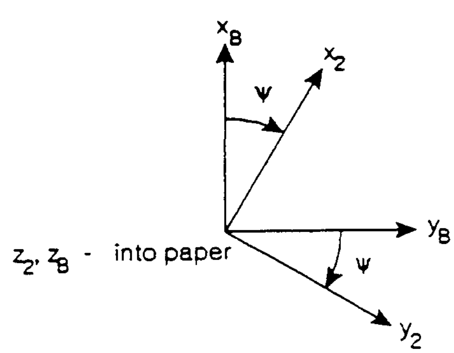
$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & c\phi & -s\phi \\ 0 & s\phi & c\phi \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_R$$

b. Next, transform from frame "1" to a second intermediate frame "2", through pitch as follows:



$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_2 = \begin{bmatrix} c\theta & 0 & s\theta \\ 0 & 1 & 0 \\ -s\theta & 0 & c\theta \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_1$$

c. Finally, transform frame "2" to the Body frame "B" through yaw as follows:



$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_B = \begin{bmatrix} c\psi & -s\psi & 0 \\ s\psi & c\psi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_2$$

The overall transformation is then:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_B = \begin{bmatrix} c\psi & -s\psi & 0 \\ s\psi & c\psi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} c\theta & 0 & s\theta \\ 0 & 1 & 0 \\ -s\theta & 0 & c\theta \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & c\phi & -s\phi \\ 0 & s\phi & c\phi \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_R$$

Multiplying out:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_B = \begin{bmatrix} c\psi c\theta & c\psi s\theta s\phi - s\psi c\phi & c\psi s\theta c\phi + s\psi s\phi \\ s\psi c\theta & s\psi s\theta s\phi + c\psi c\phi & s\psi s\theta c\phi - c\psi s\phi \\ -s\theta & c\theta s\phi & c\theta c\phi \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_R$$

Note that the above matrix is similar to the CBN matrix described in paragraph 6.5.2. It is not exactly identical because an additional transformation is required to go from the "B" frame to the "N" frame.

If both orientation and software boresight is to be performed, the overall transformation would be:

Equation (1)

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_B = \begin{bmatrix} \Psi_{B/S} \end{bmatrix} \begin{bmatrix} \Theta_{B/S} \end{bmatrix} \begin{bmatrix} \Phi_{B/S} \end{bmatrix} \begin{bmatrix} \Psi_O \end{bmatrix} \begin{bmatrix} \Theta_O \end{bmatrix} \begin{bmatrix} \Phi_O \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_R$$

Where the subscript "B/S" or "O" indicates either a boresight or orientation matrix of the form previously described.

If no correction is required in a particular axis, the appropriate Ψ, Θ, or Φ matrix is replaced by the identity matrix:

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Polarity conventions: The polarity conventions for both orientation and boresight entries are identical and will be illustrated by the following example:

Example 1

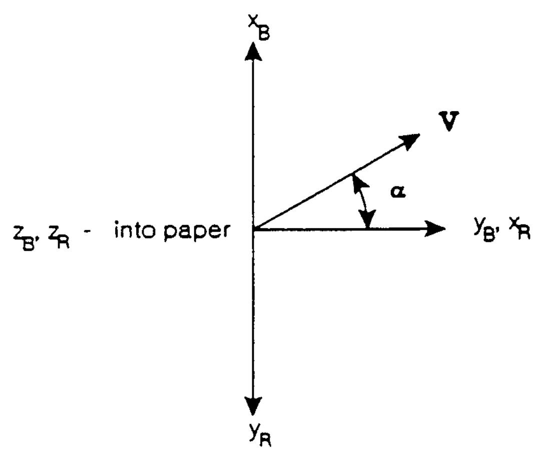
Given:

1. The INU installation is such that the handle end of the INU faces the tail of the aircraft.

2. A +90 yaw orientation has been entered. Pitch and roll orientation, as well as all boresight corrections are zero.

3. The aircraft is flying and the INU is sensing a velocity V.

Graphically:



Equation (1) reduces down to:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_B = \begin{bmatrix} \Psi_O \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_R = \begin{bmatrix} c\psi & -s\psi & 0 \\ s\psi & c\psi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_R$$

Ψ = 90 degrees, therefore, putting in values:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_B = \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} V\cos(\alpha) \\ -V\sin(\alpha) \\ 0 \end{bmatrix}_R = \begin{bmatrix} V\sin(\alpha) \\ V\cos(\alpha) \\ 0 \end{bmatrix}_B$$

The velocity sensed by the INU has been correctly transformed into body axis coordinates.

Table V-3 - ASCII Representation of Orient Status Word During Miscellaneous Parameter 36 Read

CHAR	BITS	VALUE	ASCII	FUNCTION
1	1-2	00	D	Orient OFF/Boresight OFF
		01	P	Prohibited (Note 1)
		10	O	Orient ON/Boresight OFF
		11	B	Orient ON/Boresight ON
2,3	3-8	000000	00	Basic Orientation (Note 2)
		000001	01	" "
		-		
		100000	32	" "
		-		
		111110	62	" "
		111111	63	" "
4	9-10	00	P	Compare PASS / Store COMPLETE
		01	I	Reserved
		10	F	Compare FAIL / Store COMPLETE
		11	B	Reserved
5	11-13	000	0	Range Check (Note 3) BO/BA/TO IN
		001	1	Function Reserved
		010	2	" "
		011	3	" "
		100	4	" "
		101	5	Range Check TO/BO OUT BA IN
		110	6	" " TO/BA OUT BO IN
		111	7	" " BO/BA/TO OUT
6	14-16	000	0	Function Reserved

Note 1: Appearance of binary pattern 01 would represent entry of a prohibited command. This pattern should not occur in normal operation and its appearance in these bit locations would most likely indicate a memory failure.

Note 2: The ASCII characters shall be two numeric digits in the range of 00 to 63 as determined by the binary value represented by the various basic orientation combinations.

Note 3: BO = Basic Orientation, BA = Boresight Correction Angle, TO = Total Orientation, OUT = OUT OF RANGE, IN = WITHIN RANGE

Table V-4 - Orient Status Word

DATA BIT	VALUE	FUNCTION DESCRIPTION	
1-2	00	Orient OFF/Boresight OFF	(Default)
	01	Prohibited	(Note 1)
	10	Orient ON/Boresight OFF	
	11	Orient ON/Boresight ON	
3-4	00	0 Degree Roll Orientation	(Default)
	01	90 Degree " "	
	10	180 Degree " "	
	11	270 Degree " "	
5-6	00	0 Degree Pitch Orientation	(Default)
	01	90 Degree " "	
	10	180 Degree " "	
	11	270 Degree " "	
7-8	00	0 Degree Yaw Orientation	(Default)
	01	90 Degree " "	
	10	180 Degree " "	
	11	270 Degree " "	
9	0	Entered Data Compare PASS	(Note 2)
	1	" " " FAIL	
10	0	Boresight Data Store COMPLETE	
	1	" " " INCOMPLETE	(Note 3)
11	0	Basic Orientation WITHIN RANGE	(Note 4)
	1	" " OUT OF RANGE	
12	0	Boresight Angles WITHIN RANGE	(Note 5)
	1	" " OUT OF RANGE	
13	0	Total Orientation WITHIN RANGE	(Note 6)
	1	" " OUT OF RANGE	
14	0	Function Reserved	
15	0	Function Reserved	
16	0	Function Reserved	

Remark: Default values represent functions or conditions which shall be assumed by INU upon power-up unless otherwise programmed. See following notes.

TABLE V-4 (NOTES)

Note 1: This value represents a prohibited command and shall not be permitted. Attempt to enter this command shall invoke an "illegal command" error.

Note 2: This bit shall be set subsequent to any data entry command when the compare option is specified. This bit shall be set to logic 0 if the compare was successful, logic 1 if the compare was unsuccessful.

Note 3: This bit shall be set to logic 1 upon receipt of a command enter boresight angles via the data bus in words D01-04, D01-05, and D01-06. The bit shall remain set until successful completion of storage of all boresight angles, at which time it shall be reset to 0.

Note 4: This bit is set to 1 if an optional orientation, as defined in Table V-1, is selected.

Note 5: This bit is set to 1 if the selected boresight correction values exceed the values specified in Table V-2.

Note 6: This bit is set to 1 if either boresight or orientation is out of range.

APPENDIX VI

MULTIPLEX DATA BUS OPERATION

AND INU MESSAGE FORMATS

60. MULTIPLEX DATA BUS OPERATION AND INU MESSAGE FORMATS

60.1 Scope and Purpose

60.1.1 Scope

This appendix defines requirements for the multiplex data bus portion of the INU hardware. Conventional stand alone navigation systems are discussed. Systems where the INU is integrated with a central computer are discussed. The unique CDU interface is no longer part of this specification and is now covered in SNU 84-1/F-16. Therefore I02, I03, I04, F01, and P02 have been deleted.

60.1.2 Purpose

The purpose of this document is to establish uniform requirements for an INU which uses multiplex data buses as interface devices. A secondary purpose is to identify unique subaddress codes and data message word and bit assignments. The document will promote technical interchange by further defining digital interfaces.

60.2 Applicable Documents

STANDARDS

MIL-STD-1553B 21 Sept 1978 Notice 1, 12 Feb 1980	Aircraft Internal Time Division Command/Response Multiplex Data Bus

SPECIFICATIONS

MIL-E-6051D(1) 05 Jul 1968	Electromagnetic Compatibility Requirements Systems

60.3 Networking Data Bus Requirements

60.3.1 General

The following paragraphs outline the procedures for 'Networking' the INU data buses. All of the requirements in Section 60.4 apply to both INU data buses, with the exception of Section 60.4.4 requirements which shall not apply to Network 2.

60.3.2 Message and Word Format

The message and word formats contained herein, shall be available on both Network 1 and Network 2 data buses. Data form shall be in accordance with paragraph 60.4.2.1 and transmission method shall be as specified in Section 60.4.2.2.

60.3.3 Networking Bus Characteristics

The networking bus characteristics are as follows:

a. The INU shall be identified with only one RT address.

b. Both Network 1 and Network 2 shall use this address.

c. Network 2 (Channels A and B) is always an RT, never a BC.

60.3.4 Inter-Bus Compatibility

The INU shall be able to accept any of the defined messages, on either bus network, at any time. There shall be no combination of messages on any bus, at any time, that shall cause the INU to lock-up or enter an undefined state.

60.4 MIL-STD-1553 Requirements

60.4.1 INU/Data Bus Operation

When operating as a remote terminal, the INU components shall conform in accordance with the data bus operation, as defined in MIL-STD-1553 and Notice 1 thereto. Sole control of information transmission shall reside with the bus controller which shall initiate all transmissions. The INU shall implement a bus controller configuration in accordance with MIL-STD-1553 and paragraph 60.4.4. Requirements contained herein shall supersede those contained in MIL-STD-1553 when conflicts between the two exists. Typical multiplex data bus functional interfaces for operation under primary bus control are depicted in Figure VI-1. Multiplex data bus functional interfaces for operation under INU bus control are depicted in Figure VI-2.

60.4.1.1 Information Transfer Modes

The INU component shall use only the following modes of information transfer: (1) Bus controller to remote terminal (RT) transfer; (2) RT to controller transfer; (3) RT to RT transfer. Broadcast commands shall not be allowed for data/information transfer, i.e. I06, I01, etc. However, the INU shall be capable of receiving the synchronize mode commands via a broadcast transfer in addition to the normal transfers, see paragraphs 60.4.2.2.2 and 60.4.2.2.2.7.

60.4.2 Characteristics

60.4.2.1 Data Form

Digital data shall be transmitted in a form compatible with the message and word formats contained herein. Negative quantities shall follow the 2's complement convention. Data bit number "1" as defined in Table VI-8 shall be the most significant bit and data bit "16" shall be the least significant bit. Word formats which define least significant bits to a higher resolution than the computational capability of the INU shall be filled with logic zeros subsequent to the least significant INU computed bit. Any unused bit positions in a word shall be transmitted as logic zeros.

60.4.2.2 Transmission Method

60.4.2.2.1 Transmission Rate

The transmission rate on the bus shall be 1.0 megabit per second with a long term stability of ± 0.01 percent (i.e., ± 100 Hz). The short term stability (i.e., stability over a 1.0 second interval) shall be at least 0.001 percent (i.e., ± 10 Hz).

60.4.2.2.2 Command Word

A command word shall be comprised of a sync waveform, address, transmit/receive bit, subaddress/mode, data word count/mode code, and a parity bit, except as modified by 60.4.2.2.2.7.

60.4.2.2.2.1 Sync

The command sync waveform shall be an invalid Manchester waveform. The width shall be three bit times, with the waveform being positive for the first one and one-half bit times, and then negative for the following one and one-half bit times. If the next bit following the sync is a logic zero, then the last half of the sync waveform shall have an apparent width of two clock periods due to the Manchester encoding.

60.4.2.2.2.2 Address

The next five bits following the sync shall be the RT address. All 1's shall indicate a decimal address of 31 broadcast and shall not be used except as stated in paragraph 60.4.2.2.2.7 and 60.4.1.1. All 0's shall indicate a decimal address of 32. This permits a maximum of 31 RT's to be attached to any one data bus. The most significant bit of the address shall be transmitted first.

60.4.2.2.2.2.1 Unique Address

Selection of the specific address shall be determined by the presence or absence of continuity between pins on the INU components input-output connectors. The presence or absence of continuity shall be established in the vehicle wiring. The INU addresses shall be established in the vehicle wiring. A zero condition shall be indicated by pin to ground continuity. All five pins shall be connector programmable. See Table VI-1 for allocated address assignments.

60.4.2.2.2.3 Transmit/Receive

The next bit following the address shall be the transmit/receive bit, which shall indicate the action required of the RT. A logic zero shall indicate the RT is to receive, and a logic one shall indicate the RT is to transmit.

60.4.2.2.2.4 Subaddress/Mode

The next five bits following the transmit/receive bit shall be utilized for either a RT subaddress or mode control, as is dictated by the individual terminal requirements. The subaddress/mode values of 00000 and 11111 are reserved for special purposes, as specified in 60.4.2.2.2.7, and shall not be utilized for any other function.

60.4.2.2.2.5 Word Count/Mode Code

The next five bits following the subaddress/mode control shall be the quantity of data words to be either sent out or received by the RT, with the exceptions specified in paragraph 60.4.2.2.2.7. A maximum of 32 data words may be transmitted or received in any one message block. All 1's shall indicate a decimal count of 31, and all 0's shall indicate a decimal count of 32.

60.4.2.2.2.6 Parity

The last bit in the word shall be used for parity over the preceding sixteen bits. Odd parity shall be utilized.

60.4.2.2.2.7 Mode Control

In accordance with MIL-STD-1553, paragraph 4.3.3.5.1.7. A subaddress/mode field bit pattern of 00000 and/or 11111 shall imply that the contents of the word count field are to be decoded as a five bit mode command. The mode code indicators 00000, and 11111 shall not convey different information. The INU shall implement the following mode codes as a minimum:

Mode Code	Function
00001	Synchronize (without data)
00010	Transmit Status Word
00011	Initiate Self Test (RT)
00100	Transmitter Shutdown
00101	Override Transmitter Shutdown
01000	Reset Remote Terminal
10001	Synchronize (with data)
10010	Transmit Last Command
10011	Transmit BIT Word

The two synchronize mode commands shall also be implemented as broadcast commands. The synchronize mode commands shall only apply to the bus network that it is received on (see paragraph 60.4.3.2).

60.4.2.2.2.7.1 Reset Remote Terminal

As per MIL-STD-1553 paragraph 4.3.3.5.1.7.9. An RT receiving the Reset Remote Terminal mode code shall respond with a status word as specified in MIL-STD-1553 paragraph 4.3.3.5.3 and then reset. While the RT is being reset, the RT shall respond to a valid command with one of the following three responses: RT offline (no response on the data bus), status word transmitted with the busy bit set, or normal response. If any data is transmitted from the RT while it is being reset, the information content of the data must be valid. An RT receiving this mode code shall complete the reset function within 5.0 milliseconds following transmission of the status word.

60.4.2.2.2.7.2 Initiate Self-Test

As per MIL-STD-1553 paragraph 4.3.3.5.1.7.4. An RT receiving the Initiate Self-Test mode code shall respond with a status word as specified in MIL-STD-1553 paragraph 4.3.3.5.3 and then initiate the self-test function. While the self-test is in progress, the RT shall respond to a valid command with one of the following three responses: RT offline (no response on the data bus), status word transmitted with the busy bit set, or normal response. If any data is transmitted from the RT while it is in self-test, the information content of the data must be valid. An RT receiving this mode code shall complete the self-test function within 20.0 milliseconds following transmission of the status word.

60.4.2.2.2.7.3 Transmit Bit Word

Per MIL-STD-1553 paragraph 4.3.3.5.1.7.14. Any bit(s) set to a logic one in the BIT word shall indicate a failure in the INU's MIL-STD-1553 Terminal.

60.4.2.2.2.8 Allocated Subaddress Mode

Table VI-2 lists INU subaddresses which have been allocated. Use of other subaddresses for the INU system shall be subject to approval by the procuring activity.

60.4.2.2.2.9 Instrumentation Bit

Bit 10 of the command word shall be set to a "1".

60.4.2.2.2.10 Variable Message Block

The INU RT shall be able to transmit a subset of any message block defined in Table VI-2 (i.e., send the first n-x words of a message, where n is the defined word count of that message in Table VI-2 and x ≤ n-1). This shall be done by varying the word count up to the maximum defined by a particular subaddress in Table VI-2. The INU shall receive and use the word count to determine the number of words in a message block.

60.4.2.2.3 Status Word

The following bits, message error, instrumentation, broadcast command received, subsystem flag, and terminal flag (MIL-STD-1553, paragraph 4.3.3.5.3.3, 4.3.3.5.3.4, 4.3.3.5.3.7, and 4.3.3.5.3.9 and 4.3.3.5.3.11) shall be implemented. Other bits may be optionally implemented, but may not be implemented as constraints on system operation.

60.4.2.3 Transmission Line

60.4.2.3.1 Cable Coupling

Transformer coupling as defined in MIL-STD-1553, paragraph 4.5.1.5.1 shall be used.

60.4.2.3.2 Wiring and Cabling for EMC

For purposes of electromagnetic compatibility (EMC), the wiring and cabling provisions of MIL-E-6051 shall apply.

60.4.2.4 RT/Bus Interface Circuits

60.4.2.4.1 RT Output Levels

The RT signal output circuitry shall be capable of driving the cable specified in MIL-STD-1553, paragraph 4.5.1.1, and not less than 33 other RT's, as specified herein, each attached to the cable by means of a cable stub with a maximum length of 20 feet. The output circuitry shall maintain the specified operation with the exception of a 25 percent maximum reduction of the data bus signal amplitude in the event that one of the RT's has a fault that causes it to reflect the fault impedance specified in MIL-STD-1553, paragraph 4.5.1.5.1.2, onto the bus. The RT signal output voltage shall be within the range of 18.0 to 27.0 volts, peak-to-peak line-to-line, when measured at the RT output, terminated into a 70 ohm ± 5 percent resistive load. The RT signal voltage shall be greater than or equal to 18.0 volts Peak-to-Peak (P-P) line-to-line at the RT output when terminated into a 143 ohm ± 1 percent resistive load.

60.4.2.4.2 RT Input Impedance

The magnitude of the RT input impedance, when the RT is not transmitting, or has power removed, shall be a minimum of 1000 ohms within the frequency range of 75 kHz to 1.0 MHz. This impedance is that measured line-to-line at point A on Figure 9, MIL-STD-1553.

60.4.3 Remote Terminal Operation

The illegal command option as defined in MIL-STD-1553, paragraph 4.4.3.4 shall not be implemented. The INU shall respond "in form" to all valid commands, i.e., respond with status and the proper number of data words as defined by the command word.

60.4.3.1 RT Time Out Requirements

When the INU is acting as a remote terminal, it shall time out if data is not received. This time out shall occur no sooner than 52 microseconds and no later than 58 microseconds subsequent to the receipt of an RT to RT receive command. These times are referenced from the end of the receive command to the beginning of the first expected data word.

60.4.3.2 Time Tag

Timer information shall be output as specified in the message formats of Table VI-8. The timer for each network shall be free running and independently controllable with an LSB of 64 microseconds and shall be reset to logic 0 or preset to a defined value via the synchronize mode commands defined in 60.4.2.2.2.7. The time tag shall reflect the time at which its associated data was sampled, i.e. at the INU validity point.

60.4.3.3 Data Coherency/Sample Consistency

The INU shall maintain the time coherence of information transferred over the bus. It shall provide mutually consistent samples of information and deterministic transport lags. The INU design shall insure that messages transmitted over the bus contain only mutually consistent samples of information. Different words used to transmit multiple precision parameters shall all be members of the same set. Functionally related parameters updated at the same rate shall all be members of the same sample set. Suitable buffering and transmission control logic shall be provided to prevent the transmission of a partially updated message that would contain mutually inconsistent data. Indicator bits shall be consistent with their corresponding data without respect to refresh or transmission rates. The only exception to these requirements are as noted in Table VI-2 and word formats contained herein.

60.4.3.4 Data Wraparound

The INU shall implement a data wraparound capability with subaddress 28 (11100). The RT shall be capable of receiving and transmitting 32 data words at this subaddress. A valid receive message with this subaddress to the INU shall cause the INU to store the commanded number of data words. A valid transmit command with this subaddress to the INU shall cause the INU to transmit the commanded number of stored data words. The data words shall be transmitted in the same order as the words received by this subaddress. This may be used to verify the output symmetry in sections 4.5.2.1.1.4 and 4.5.2.2.1.4 of MIL-STD-1553. Any intervening valid receive command to the INU may alter the content of the stored data.

60.4.3.5 Subsystem Status

The INU shall, upon command, transmit its self-test/status information. Status here refers to Mode, State, Health, or Identification information for the complete RT, BC, and all other INU components. I14 subaddress 10100 (20) shall be reserved for this function. The INU shall be capable of transmitting at least one data word for this subaddress. The first data word transmitted by the RT shall be all zeros to indicate that the RT, BC, and INU components have no failures and nonzero if there are any failures; this word reflects current status. Any nonzero value shall be reflected via the subsystem flag or terminal flag as appropriate. Analog output failures shall not cause non-zero values in I14-01 unless these failures result in digital failures. Subsequent data words may be used to expound on the failures and to transmit mode, state, or identification information. The specific bit definitions shall be defined by each manufacturer based upon their particular design within the above constraints.

60.4.4 Bus Controller

The INU shall perform the function of Bus Controller when the double-ended bus control discrete is a logic 0 (see Appendix III), or if the discrete is left floating or if the driver is powered down. The INU shall relinquish control of the bus if the bus control discrete is a logic 1 (see Appendix III). The input circuits of the receiver shall present a minimum impedance of 10 kilohms. Short circuit of the bus control discrete shall not damage the INU. The bus control function shall be inhibited whenever any unused terminal address line (P-132 pins 34 through 38) is strapped to the Bus Control Discrete high (P-131 pin 51) while the Bus Control Discrete low (P-131 pin 17) is tied to ground.

60.4.4.1 Two Bus Control System

The INU will function as a remote terminal when the bus control discrete is a logic 1 (2.4 VDC Minimum). When the primary bus controller is operational, it will raise the bus control discrete 20 ms before initiating activity. The INU should cease controller operation immediately upon detection of a high bus control discrete. INU must, after detecting the bus control discrete low for 20 ms, monitor each bus for valid command words to determine the presence of data bus traffic prior to assuming control of the data bus. Failure to detect valid command words on the data buses within 40 ms subsequent to the above detection period shall constitute quiet bus conditions and bus controller operation should begin. Detection of valid commands on either data bus while in this time period shall inhibit the INU Bus Controller function. However, the INU shall continue to monitor for bus traffic and shall initiate bus controller operation if bus traffic ceases for any subsequent 40 ms period.

60.4.4.2 Bus Control Functions

The bus control functions are to supervise all serial digital data transmissions and to manage the data bus redundancy.

60.4.4.2.1 Transmission Supervision

The bus control function shall initiate all communication sequences by issuing command words over the data bus requesting subsystems to transmit or receive data. Refresh rate, message block identification, subaddress fields and word counts required to generate the command words are contained in Table VI-2. The sequence of these commands shall be established by operational software in the INU. The bus control function shall also monitor each communication sequence and initiate corrective action for command words which are not properly executed. All refresh rates shall be construed to be minimum computation rates.

60.4.4.2.2 Redundancy Management

The bus controller shall manage the serial digital data bus redundancy. The error handling function of the INU bus controller shall monitor the bus transmissions for the errors listed in MIL-STD-1553, paragraph 4.4.1.1. Errors detected during the transmission of a data block on one bus will cause an immediate retry, within the same frame, of the same message on the opposite bus for the next attempt to transmit data.

60.4.4.3 INU Command Table Requirements

When bus control is transferred to the INU, the INU shall perform the bus control function as defined in Table VI-3.

60.4.4.4 Bus Controller Time Out Requirement

When acting as a bus controller, the INU shall time out when awaiting a response to an issued command but not sooner than 12 microseconds.

Table VI-1 - Back-Up Control Function Avionic Subsystem Terminal Addresses

TERMINAL ADDRESS	SUBSYSTEM
01000	Unique Control Display Unit (UCDU)
01100	Heads-Up-Display (HUD)
10000	Radar Display
10100	Radar
10101	Generalized CDU #1
10110	Generalized CDU #2
10111	Generalized CDU #3
11000	Stores Management System
11010	Global Positioning System
11100	Central Air Data Computer (CADC)
11111	Prohibited Address

Note: All five bits of the terminal address field shall be connector programmable. The INU terminal address shall not be any address listed in Table VI-1 above or 00100, 00101, or 10010. Terminal addresses 00100, 00101, and 10010 as determined from the aircraft connector, are reserved and shall not be used by the integrator. The aircraft system integrator may define any other terminal addresses. CDU #2 shall be used during INU Back-Up Bus Control operation.

60.4.5 INU Message Block/Word Formats

Message blocks shown define INU transmit/receive requirements when operating as a remote terminal.

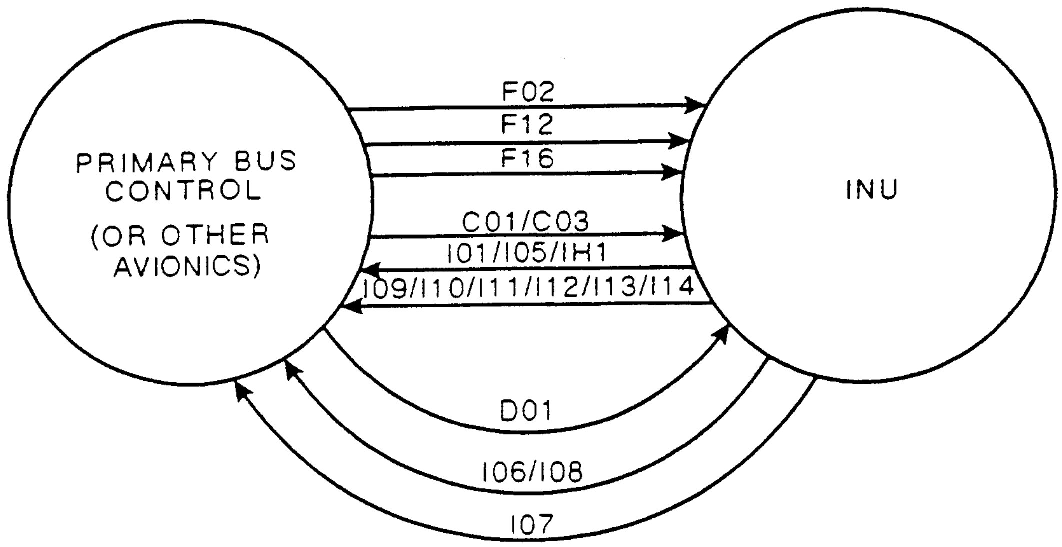
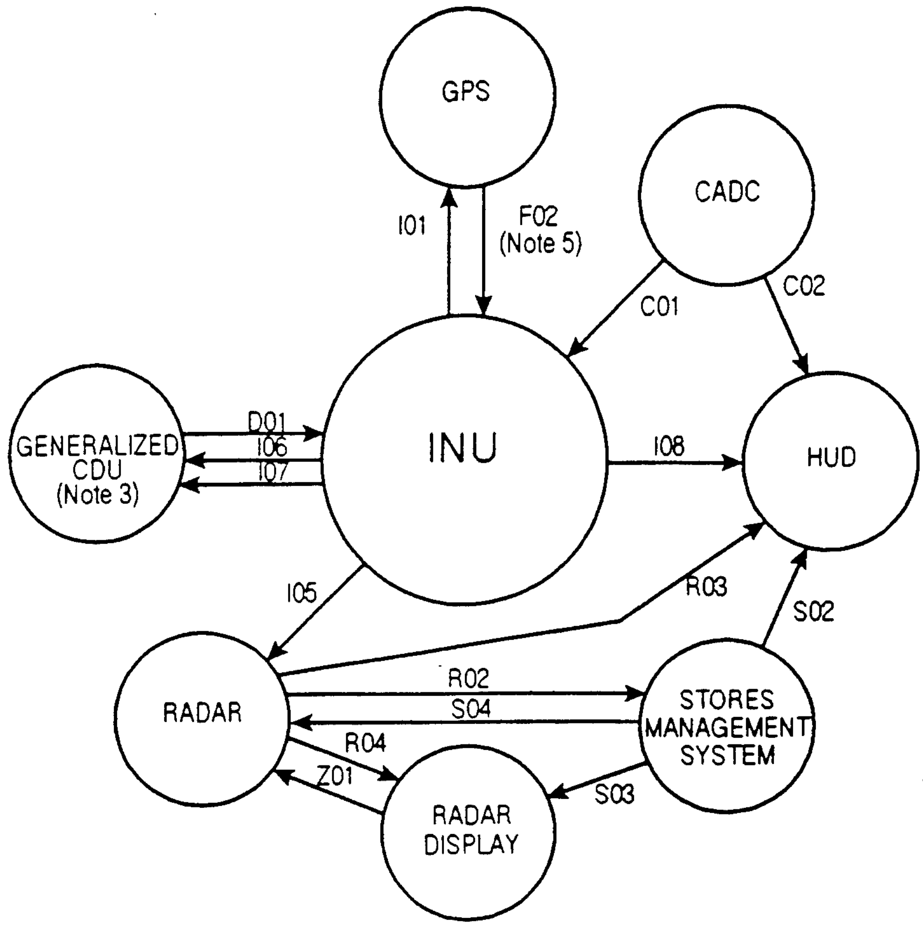


Figure VI-1
Typical Multiplex Data Bus Functional Diagram
(Under Primary Bus Control)



NOTE 1: Deleted

NOTE 2: Deleted

NOTE 3: CDU Panel/Operator interface independent of INU software.

NOTE 4: Deleted

NOTE 5: F02 correction vector must be computed by an external computer (i.e. other than the INU) that accepts sensor information and INU data to compute the corrections to the INU.

Figure VI-2
Multiplex Data Bus Functional Diagram
(Under INU Bus Control)

Table .I-2 - Transmitting Subsystem Subaddress/Word Count/Rates

TRANSMITTING SUBSYSTEMS				(See Note)RATE(TIMES/SECOND)	
SUBSYSTEM	BLOCK ID	SUBADDRESS	WORD COUNT	REFRESH	TRANSMIT
INU	I01	10000	32	50	50
	I05	10000	13	50	50
	I06	11001	32	*	12.5
	I07	11011	32	2.5	12.5
	I08	11001	31	*	50
	I09	10011	23	200	200
	I10	10010	28	12.5	12.5
	I11	10110	26	As Req	As Req
	I12	10111	15	As Req	As Req
	I13	11000	24	As Req	As Req
	IH1	11010	17	200	200
	I14	10100	32	As Req	As Req
CDU #2	D01	11010	7	5	12.5
CADC	C01	10000	10	20	25
	C02	10000	9	20	25
	C03	10000	4	20	25
RADAR DISPLAY	Z01	10001	1	6.25	6.25
RADAR	R02	10001	3	50	50
	R03	10000	5	50	50
	R04	10010	9	25	25
STORES MGT SYSTEM	S02	10000	4	50	50
	S03	10000	2	1.5625	1.5625
	S04	10000	4	50	50
GPS(EXT.COMP.)	F02	10001	30	N/A	5.0 Max
*Refresh Rates as specified in Formats section					

Note: All rates are minimum. Subsystems may refresh at any higher rates consistent with their capability. Minimum rates for INU messages shall not imply an infinite rate requirement, but shall imply that when a maximum transmit/receive rate described by 16 back-to-back 32 word messages, with intermessage gaps of not more than 2 microseconds, are requested, the INU data shall be valid. Whenever message rates exceed those described here, any INU function or performance, other than bus communication, shall be unaffected. Upon return to rates described here, the bus communication shall recover to normal operation.

Table VI-2a - Receiving Subsystem Subaddress/Word Count/Rates

RECEIVING SUBSYSTEMS				(See Note) RATE (TIMES/SECOND)	
SUBSYSTEM	BLOCK ID	SUBADDRESS	WORD COUNT	REFRESH	TRANSMIT
INU	C01	11110	10	20	25
	C03	10011	4	20	25
	D01	11010	7	5	12.5
	F02	10001	30	N/A	5.0 Max
	F12	10110	25	As Req	1.5625
	F16	10101	29	As Req	1.5625
	F17	10010	2	As Req	As Req
CDU #2	I06	11001	32	*	12.5
	I07	11011	32	2.5	12.5
RADAR DISPLAY	R04	10100	9	25	25
	S03	10011	2	1.5625	1.5625
RADAR	I05	10001	13	50	50
	S04	10010	4	50	50
	Z01	10011	1	6.25	6.25
HUD	C02	11101	9	20	25
	I08	11001	31	*	50
	R03	11011	5	50	50
	S02	11100	4	50	50
STORES MGT SYSTEM	R02	10001	3	50	50
GPS	I01	10001	32	50	50
* Refresh rates as specified in Word formats Section.					

Note: All rates are minimum. Subsystems may refresh at any higher rates consistent with their capability. Minimum rates for INU messages shall not imply an infinite rate requirement, but shall imply that when a maximum transmit/receive rate described by 16 back-to-back 32 word messages, with intermessage gaps of not more than 2 microseconds, are requested, the INU data shall be valid. Whenever message rates exceed those described here, any INU function or performance, other than bus communication, shall be unaffected. Upon return to rates described here, the bus communication shall recover to normal operation.

Table VI-3 - Back-Up Bus Command Table

GENERALIZED CDU INTERFACE								
FRAME NUMBER	1	2	3	4	5	6	7	8
FRAME TIME (MILLISECONDS)	20	40	60	80	100	120	140	160
	I08	I08	I08	I08	I08	I08	I08	I08
	I05	I05	I05	I05	I05	I05	I05	I05
	I01	I01	I01	I01	I01	I01	I01	I01
	S02	S02	S02	S02	S02	S02	S02	S02
	S04	S04	S04	S04	S04	S04	S04	S04
	R02	R02	R02	R02	R02	R02	R02	R02
	R03	R03	R03	R03	R03	R03	R03	R03
	F02	C02	I06	C02	Z01	C02	I06	C02
		C01	I07	C01		C01	I07	C01
		R04	D01	R04		R04	D01	R04
FRAME NUMBER	9	10	11	12	13	14	15	16
FRAME TIME (MILLISECONDS)	180	200	220	240	260	280	300	320
	I08	I08	I08	I08	I08	I08	I08	I08
	I05	I05	I05	I05	I05	I05	I05	I05
	I01	I01	I01	I01	I01	I01	I01	I01
	S02	S02	S02	S02	S02	S02	S02	S02
	S04	S04	S04	S04	S04	S04	S04	S04
	R02	R02	R02	R02	R02	R02	R02	R02
	R03	R03	R03	R03	R03	R03	R03	R03
		C02	I06	C02	Z01	C02	I06	C02
		C01	I07	C01		C01	I07	C01
		R04	D01	R04		R04	D01	R04

Table VI-3 - Back-Up Bus Command Table (continued)

GENERALIZED CDU INTERFACE								
FRAME NUMBER	17	18	19	20	21	22	23	24
FRAME TIME (MILLISECONDS)	340	360	380	400	420	440	460	480
	I08 I05 I01 S02 S04 R02 R03 S03	I08 I05 I01 S02 S04 R02 R03 C02 C01 R04	I08 I05 I01 S02 S04 R02 R03 I06 I07 D01	I08 I05 I01 S02 S04 R02 R03 C02 C01 R04	I08 I05 I01 S02 S04 R02 R03 Z01	I08 I05 I01 S02 S04 R02 R03 C02 C01 R04	I08 I05 I01 S02 S04 R02 R03 I06 I07 D01	I08 I05 I01 S02 S04 R02 R03 C02 C01 R04
FRAME NUMBER	25	26	27	28	29	30	31	32
FRAME TIME (MILLISECONDS)	500	520	540	560	580	600	620	640
	I08 I05 I01 S02 S04 R02 R03	I08 I05 I01 S02 S04 R02 R03 C02 C01 R04	I08 I05 I01 S02 S04 R02 R03 I06 I07 D01	I08 I05 I01 S02 S04 R02 R03 C02 C01 R04	I08 I05 I01 S02 S04 R02 R03 Z01	I08 I05 I01 S02 S04 R02 R03 C02 C01 R04	I08 I05 I01 S02 S04 R02 R03 I06 I07 D01	I08 I05 I01 S02 S04 R02 R03 C02 C01 R04

Table VI-4
Summary of I06, I07, I09, I10, I11, I12 and I13 Outputs

I06-01	INU Control Word 1.
I06-02	Time Tag - Referenced to the beginning of the velocity computation cycle (INS Control Word 2).
I06-03 thru I06-08	Velocity X, Y, Z - Velocity components referenced to the platform axis.
I06-09	Platform Azimuth - Clockwise angle from the platform X axis to the vehicle mounting pads
I06-10	Roll - Referenced to local earth level
I06-11	Pitch - Referenced to local earth level
I06-12	Present True Heading
I06-13	Present Magnetic Heading
I06-14	Great Circle Steering Error - Defined as a function of Steering Mode: Great Circle Steering - Bit 15 of D01-02 set to Logic "0" See Theta SE on Figure 11 Selected Course Steering-Bit 15 of D01-02 set to Logic "1" Theta SE is defined to be zero
I06-15	Computed Course Deviation-Defined as a function of Steering Mode: Great Circle Steering - Bit 15 of D01-02 set to Logic "0" See Theta CD on Figure 11 Selected Course Steering-Bit 15 of D01-02 set to Logic "1" Theta CD = -(Magnetic bearing to position where bit 15 was set to Logic "1") ± (180 degrees) + (Selected Magnetic Course)
I06-16	Time to Steerpoint = Predicted time based on groundspeed computed from using last computed wind assuming that present true air speed shall remain constant
I06-17	Distance to Steerpoint
I06-18	Relative Bearing to Steerpoint: RB = TB - TH
I06-19	Relative Bearing to nth Waypoint/Markpoint: RB = TB - TH
I06-20	Time to nth Waypoint/Markpoint = Predicted time based on groundspeed computed from using last computed wind assuming that present true air speed shall remain constant
I06-21	Distance to nth Waypoint/Markpoint
I06-22	INU Control Word 3
I06-23	nth Waypoint/Markpoint Latitude (MSP)
I06-24	nth Waypoint/Markpoint Latitude (LSP)
I06-25	nth Waypoint/Markpoint Longitude (MSP)
I06-26	nth Waypoint/Markpoint Longitude (LSP)
I06-27	Selected Magnetic Course to Steerpoint = Desired magnetic ground track to Steerpoint (used with Great Circle Steering)
I06-28	Selected Magnetic Course = Desired magnetic ground track from point where Selected Course Steering was selected
I06-29	Magnetic Heading to nth Waypoint/Markpoint = Magnetic course to selected position corrected for Drift Angle as computed using last computed wind assuming present true air speed shall remain constant
I06-30	True Air Speed = Last true air speed received from the central air data computer or manually input via MISC PARAMETER INSERT
I06-31	Present Magnetic Ground Track
I06-32	Drift Angle

Table VI-4
Summary of I06, I07, I09, I10, I11, I12 and I13 Outputs
(continued)

I07-01	nth Waypoint/Markpoint Spheroid/UTM Grid Zone (MSP)
I07-02	nth Waypoint/Markpoint UTM Grid Zone (LSP)
I07-03	nth Waypoint/Markpoint 100,000 Meter UTM Area
I07-04	nth Waypoint/Markpoint UTM Easting
I07-05	nth Waypoint/Markpoint UTM Northing
I07-06	"Inertial Display" Present Position Latitude (MSP)
I07-07	"Inertial Display" Present Position Latitude (LSP)
I07-08	"Inertial Display" Present Position Longitude (MSP)
I07-09	"Inertial Display" Present Position Longitude (LSP)
I07-10	"Inertial Display" Present Position Spheroid/UTM Grid Zone (MSP)
I07-11	"Inertial Display" Present Position UTM Grid Zone (LSP)
I07-12	"Inertial Display" Present Position 100,000 Meter UTM Grid Area
I07-13	"Inertial Display" Present Position UTM Easting
I07-14	"Inertial Display" Present Position UTM Northing
I07-15	Entered True Heading
I07-16	Entered Magnetic Heading
I07-17	Entered Magnetic Variation
I07-18	Computed Magnetic Variation
I07-19	Align Time and Status
I07-20	Wind Direction = Direction from which the wind blows, i.e. the angle measured clockwise from True North to the head of the wind vector, plus 180 degrees.
I07-21	Wind Velocity and Last Mark Point Code
I07-22	Present Ground Speed
I07-23	Present Ground Track
I07-24	Predicted Ground Speed = Ground Speed computed from last computed wind assuming that present true air speed shall remain constant
I07-25	Present Convergence Factor in Use (Grid Mode)
I07-26	Present Grid Heading = Vehicle Heading referenced to Grid North
I07-27	Desired Grid Heading = Desired Grid Course corrected for Drift Angle as computed using last computed wind assuming that present true air speed shall remain constant
I07-28	Position Error North (AUXILIARY and OVERFLY update modes)
I07-29	Position Error East (AUXILIARY and OVERFLY update modes)
I07-30 thru I07-32	INU Miscellaneous Data

Table VI-4
Summary of I06, I07, I09, I10, I11, I12 and I13 Outputs
(continued)

I09-01	INU Mode Word
I09-02	Time Tag
I09-03	X Velocity (MSP)
I09-04	X Velocity (LSP)
I09-05	Y Velocity (MSP)
I09-06	Y Velocity (LSP)
I09-07	Z Velocity (MSP)
I09-08	Z Velocity (LSP)
I09-09	Platform Azimuth
I09-10	Roll
I09-11	Pitch
I09-12	Roll Rate (p)
I09-13	Pitch Rate (q)
I09-14	Yaw Rate (r)
I09-15	Longitudinal Acceleration (n_x)
I09-16	Lateral Acceleration (n_y)
I09-17	Normal Acceleration (n_z)
I09-18	Platform Azimuth Time Tag
I09-19	Roll Time Tag
I09-20	Pitch Time Tag
I09-21	Roll Axis Angular Acceleration
I09-22	Pitch Axis Angular Acceleration
I09-23	Yaw Axis Angular Acceleration
I10-01	Time Tag
I10-02	X Axis Residual Tilt
I10-03	Y Axis Residual Tilt
I10-04	Z Axis Residual Tilt
I10-05	CNExx
I10-06	CNExx
I10-07	CNExy
I10-08	CNExy
I10-09	CNExz
I10-10	CNExz
I10-11	CNEyx
I10-12	CNEyx
I10-13	CNEyy
I10-14	CNEyy
I10-15	CNEyz
I10-16	CNEyz
I10-17	CSNxx
I10-18	CSNxy
I10-19	CSNxz
I10-20	CSNyx
I10-21	CSNyy
I10-22	CSNyz
I10-23	Altitude Feedback Constant
I10-24	Altitude Feedback Constant
I10-25	Velocity Feedback Constant
I10-26	Velocity Feedback Constant
I10-27	Acceleration Feedback Constant
I10-28	Acceleration Feedback Constant

Table VI-4
Summary of I06, I07, I09, I10, I11, I12 and I13 Outputs
(continued)

I11-01	Reserved
I11-02	Accelerometer Bias Uncertainty
I11-03	(X,Y,Z) Accelerometer Scale Factor (SF) Uncertainty
I11-04	X Gyro Bias Uncertainty
I11-05	Y Gyro Bias Uncertainty
I11-06	Z Gyro Bias Uncertainty
I11-07	(X,Y,Z) Gyro SF Uncertainty
I11-08	X Gyro Randomness
I11-09	X Gyro Correlation Time
I11-10	Y Gyro Ramdomness
I11-11	Y Gyro Correlation Time
I11-12	Z Gyro Randomness
I11-13	Z Gyro Correlation Time
I11-14	(X,Y,Z) Accelerometer Randomness
I11-15	(X,Y,Z) Accelerometer Randomness Correlation Time
I11-16	X Gyro Input/Quad Mass Unbalance (MUB) Uncertainty (Reserved)
I11-17	Y Gyro Input/Quad Mass Unbalance (MUB) Uncertainty (Reserved)
I11-18	Z Gyro Input/Quad Mass Unbalance (MUB) Uncertainty (Reserved)
I11-19	(X,Y,Z) Platform Tilt (Ground Align) Uncertainty
I11-20	(X,Y,Z) Platform Azimuth (Ground Align) Uncertainty
I11-21	(X,Y,Z) Accelerometer Nonorthogonality Uncertainty
I11-22	Reserved
I11-23	Reserved
I11-24	(X,Y,Z) Gyro Misalignment Uncertainty
I11-25	Reserved
I11-26	Reserved

Table VI-4
Summary of I06, I07, I09, I10, I11, I12 and I13 Outputs
(continued)

I12-01	Reserved
I12-02	Accelerometer Scale Factor Asymmetry
I12-03	Gravity Compensation (Reserved)
I12-04	Gravity Compensation Correlation Distance (Reserved)
I12-05	X Gyro Trending (Reserved)
I12-06	Y Gyro Trending (Reserved)
I12-07	Z Gyro Trending (Reserved)
I12-08	X Gyro Warmup (Reserved)
I12-09	X Gyro Warmup Correlation Time (Reserved)
I12-10	Y Gyro Warmup (Reserved)
I12-11	Y Gyro Warmup Correlation Time (Reserved)
I12-12	Z Gyro Warmup (Reserved)
I12-13	Z Gyro Warmup Correlation Time (Reserved)
I12-14	Accelerometer Warmup
I12-15	Accelerometer Warmup Correlation Time

Table VI-4
Summary of I06, I07, I09, I10, I11, I12 and I13 Outputs
(continued)

I13-01	Max Normal Rate For X Precision Torquing (Reserved)
I13-02	Max Normal Rate For Y Precision Torquing (Reserved)
I13-03	Max Normal Rate For Z Precision Torquing (Reserved)
I13-04	Max Slewing Rate For X Coarse Slewing (Reserved)
I13-05	Max Slewing Rate For Y Coarse Slewing (Reserved)
I13-06	Max Slewing Rate For Z Coarse Slewing (Reserved)
I13-07	Position of the Specific Force Origin, X_r
I13-08	Position of the Specific Force Origin, Y_r
I13-09	Position of the Specific Force Origin, Z_r
I13-10	Gyro Orientation About Z_b, gamma Z_o
I13-11	Gyro Orientation About Y_b, gamma Y_o
I13-12	Gyro Orientation About X_b, gamma X_o
I13-13	Accelerometer Orientation About Z_b, gamma Z_a
I13-14	Accelerometer Orientation About Y_b, gamma Y_a
I13-15	Accelerometer Orientation About X_b, gamma X_a
I13-16	Terminal Address
I13-17	Orient Status Word
I13-18	Roll Boresight Correction Angle
I13-19	Pitch Boresight Correction Angle
I13-20	Yaw Boresight Correction Angle
I13-21	Position of INU CG Along X_r
I13-22	Position of INU CG Along Y_r
I13-23	Position of INU CG Along Z_r
I13-24	Weight of the INU

Table VI-5 - Predicted Situation Output Data

BLOCK/ WORD ID	DESCRIPTION	INU MODES*										
		0	1	2	3	4	5	6	7	8	9	13
I06-16	Time to Steerpoint	X	X	X					X	X	X	X
I06-20	Time to nth Waypoint/Markpoint(WP/MP)	X	X	X					X	X	X	X
I06-29	Magnetic Heading to nth WP/MP	X	X	X					X	X	X	X
I07-24	Predicted Ground Speed	X	X	X					X	X	X	X
I07-27	Desired Grid Heading to nth WP/MP	X	X	X					X	X	X	X

*INU modes marked with an X indicate that the indicated I06 and/or I07 words shall contain all logic "0's" in the indicated INU mode. The INU modes are as follows:

- 0 - STANDBY
- 1 - STORED HEADING ALIGN
- 2 - GYROCOMPASS ALIGN
- 3 - AIR ALIGN
- 4 - NAVIGATE
- 5 - OVERFLY FIX
- 6 - AUXILIARY FIX
- 7 - CALIBRATE
- 8 - ATTITUDE
- 9 - TEST
- 13 - ORIENT

Table VI-6 - Current Situation Output Data

DESCRIPTION	INU MODES*										
	0	1	2	3	4	5	6	7	8	** 9	13
Time Tags	X							X			
Velocity X, Y, Z	X							X	X		X
Platform Azimuth	X							X			X
Roll	X							X			X
Pitch	X							X			X
Present True Heading	X							X	X	X	X
Present Magnetic Heading	X							X	X	X	X
Great Circle Steering Error	X	X	X					X	X	X	X
Computed Course Deviation	X	X	X					X	X	X	X
Distance to Steerpoint	X	X	X					X	X	X	X
Relative Bearing to Steerpoint	X	X	X					X	X	X	X
Relative Bearing to nth WP/MP	X	X	X					X	X	X	X
Distance to nth Waypoint/Markpoint	X	X	X					X	X	X	X
True Air Speed	X	X	X					X	X	X	
Present Magnetic Ground Track	X	X	X					X	X	X	X
Drift Angle	X	X	X					X	X	X	X
Present Position Latitude & Longitude	X							X			
Present Position UTM & Spheroid	X							X			
Computed Magnetic Variation	X							X			
Align Time	X							X	X		
Wind Direction	X	X	X					X	X	X	X
Wind Velocity & Last Markpoint Code	X	X	X					X	X	X	X
Present Ground Speed	X	X	X					X	X	X	X
Present True Ground Track	X	X	X					X	X	X	X
Present Convergence Factor in Use	X							X	X		X
Present Grid Heading	X							X	X	X	X
Position Error North	X	X	X					X	X	X	X
Position Error East	X	X	X					X	X	X	X
Roll Rate	X							X		X	X
Pitch Rate	X							X		X	X
Yaw Rate	X							X		X	X
Longitudinal Acceleration	X							X	X	X	X
Lateral Acceleration	X							X	X	X	X

Table VI-6 - Current Situation Output Data (continued)

DESCRIPTION	INU MODES*										
	0	1	2	3	4	5	6	7	8	** 9	13
Normal Acceleration	X							X	X	X	X
Roll Axis Angular Acceleration	X							X		X	X
Pitch Axis Angular Acceleration	X							X		X	X
Yaw Axis Angular Acceleration	X							X		X	X
X,Y,Z Acceleration	X							X	X		X
CNE xx through CNE yz	X							X	X		X
Inertial Altitude	X							X	X		X
Residual Tilts (X,Y,Z)	X							X	X		X
BITE Summary Words											
Selected Mag Course	X	X	X					X	X		X
UTM Coordinates	X							X	X		X
Velocities (North and East)	X							X	X		
CSN xx through CSN yz	X							X	X		X
Baro Feedback Constant	X							X			
(I10-23 through I10-28)											
I11 through I13	X							X			
I14								X			

* X's designated for the various INU modes indicate the words contained therein shall consist of all Logic "0's". The INU modes are as follows:

0 - STANDBY
1 - STORED HEADING ALIGN
2 - GYROCOMPASS ALIGN
3 - AIR ALIGN
4 - NAVIGATE
5 - OVER FLY FIX
6 - AUXILIARY FIX
7 - CALIBRATE
8 - ATTITUDE
9 - TEST
13 - ORIENT

** In the TEST mode, output data words designated with an X shall be set to all logic zeroes upon entry into the TEST mode. From then on, these outputs shall reflect the requirements in accordance with section 70.4.

Note: INU control/mode words I01-01, I01-29, I06-01, I06-22 are available in all power-on modes.

Table VI-7 - Mode Control Transition Logic

FROM \ TO	OFF	STBY	ORIENT	TEST	SH	BATH	GC	ATT	AIR ALIGN	NAV	OVER FLY	AUX
OFF	-	1										
STANDBY	2	-	3	4	5		6	7	8			
ORIENT	2		-	4	5		6	7	8			
TEST	2			-	5		20	7	8	9	10	11
SH	2				-	12	6	7	8	9	10	11
BATH	2					-	6	7	8	9	10	11
GC	2				5		-	7	8	9	10	11
ATT	2						13	-	8			
AIR ALIGN	2						15	7	-	16	17	18
NAV	2						14,15	7	8	-	17	18
OVERFLY	2						15	7	8	16	-	18
AUX	2						15	7	8	16	17	-

1. A
2. B+L+M+AE·O
3. K
4. J·Q
5. C·Q·AA'·Z'
6. D·Q+Z
7. I+U+{[W'·AD'·AA'·(E·S)']·[F+AB+(T'·G)+(T'·S·H)]}
8. T·E·U'
9. (F+AB)·(AA+AD+W)
10. T'·G·(AA+AD+W)
11. T'·S·H·(AA+AD+W)
12. V+W+AD'
13. (U+I) THEN D·Q·U'
14. F THEN [D·AB'·X'] (Align continued)
15. (E+F+G+H) THEN D·R·X (Align restarted)
16. F
17. T'·G
18. T'·S·H
19. RESERVED
20. D·Q
21. RESERVED

Note: Using interface should monitor I01-29 or I14-03 to verify INU mode transitions.

Table VI-7 - Mode Control Transition Logic (continued)

A:	Power-up processing complete
B:	D01-01 FSC - OFF (00000) for ≥ 1 second
C:	D01-01 FSC - SH ALIGN (00001) for ≥ 1 second
D:	D01-01 FSC = GC ALIGN (00010) for ≥ 1 second
E:	D01-01 FSC - AIR ALIGN (00011) for ≥ 1 second
F:	D01-01 FSC - NAVIGATE (00100) for ≥ 1 second
G:	D01-01 FSC - OVERFLY FIX (00101) for ≥ 1 second
H:	D01-01 FSC - AUXILIARY FIX (00110) for ≥ 1 second
I:	D01-01 FSC - ATTITUDE (01000) for ≥ 1 second
J:	D01-01 FSC = TEST (01001) for ≥ 1 second
K:	D01-01 FSC - ORIENT (01101) for ≥ 1 second
L:	ON/OFF discrete opened for ≥ 1 second
M:	INU over temp
N:	DELETED
O:	Battery voltage ≤ 16 VDC
P:	DELETED
Q:	C01/C02/C03-04 TAS ≤ 80 knots or TAS invalid
R:	Groundspeed ≤ 80 knots (current condition)
S:	Filter mode bit = 1 (F02-01 bit 2)
T:	Auto mode bit = 1 (D01-02 bit 11)
U:	ATTITUDE discrete is true
V:	Present position has been entered
W:	True or MAG HDG has been entered
X:	Groundspeed has exceeded 80 knots (latched)
Y:	RESERVED
Z:	INU has better estimate of heading or determines aircraft has moved
AA:	Degraded NAV ready or Full NAV ready set
AB:	Vehicle motion has exceeded acceptable limits
AC:	RESERVED
AD:	SH is available
AE:	Operating on Battery
AF:	DELETED
AG:	DELETED
AH:	DELETED
AI:	DELETED
AJ:	RESERVED
AK:	RESERVED

Table VI-8 - INU Message Block/Word Formats

Deleted

Table VI-8a - D01 Word Usage

CODE	INSERTED DATA	FORMAT	D01-03	D01-04	D01-05	D01-06	D01-07
00000	Present Position (L/L)	I	Q	Q	Q	Q	X
00001	Present Position UTM & Sph	II	Q	Q	Q	Q	Q
00010	True Heading (BATH Entry)	III	Q	X	X	X	X
00011	Magnetic Variation	IV	Q	X	X	X	X
00100	Selected Mag Course to SP	V	Q	X	X	X	X
00101	Waypoint/Markpoint (L/L)	VI	Q	Q	Q	Q	X
00110	Waypoint/Markpoint UTM & Sph	VII	Q	Q	Q	Q	Q
00111	Convergence Factor	VIII	Q	X	X	X	X
01000	MISC Parameter Read	IX	Q	X	X	X	X
01001	MISC Parameter Insert	X	Q	Q	Q	Q	X
01010	MAG Heading (BATH Entry)	XI	Q	X	X	X	X
01011	Selected Magnetic Course	XII	Q	X	X	X	X
01100	Orient Command/Data Insert	XIII	Q	Q	Q	Q	X
01101 thru 11111	Reserved Codes						

Note: The presence of a "Q" on the table indicates that the word is used to represent a quantity for a given Inserted Data Code. If the word is not used, indicated by an "X", it shall be transmitted as all Logic zeros.

BLOCK ID: D01 Refresh Rate = 5 Hz Transmit Rate = 12.5 Hz

The INU shall operate on D01 asynchronously (i.e. independent of rate). The INU shall not use the D01 transmit rate for data output timing purposes.

SUBADDRESS; 11010(T/R) WORD: D01-01
Signal Name - CDU Control Word 1

DATA BIT	DESCRIPTION	
1	CDU Fault Flag (See Note 1)	
2	MSB	Function Select Code (See Note 2)
3	*	
4	*	
5	*	
6	LSB	
7	MSB	Waypoint/Markpoint Select Code (See Note 3)
8	*	
9	*	
10	LSB	
11	Steerpoint Select Bit (See Note 4)	
12	D01 Message Invalid (See Note 5)	
13	Logic "0"	
14	Logic "0"	
15	Logic "0"	
16	Logic "0"	

Note 1: A logic "1" shall indicate an internally detected CDU malfunction.

Note 2: The INU shall change its operational mode if a new function select code is received on consecutive D01 transmissions for a period of at least one second. The Function Select Codes are as follows:

BINARY	FUNCTION	BINARY	FUNCTION
00000	Off	00111	Calibrate (Reserved)
00001	Stored Heading Align	01000	Attitude
00010	GC Align	01001	Test
00011	Air Align	01010	Precision Align (Reserved)
00100	Navigate	01011	Enhanced Align (Reserved)
00101	Overfly Fix	01100	High Accuracy Align (Reserved)
00110	Auxiliary Fix	01101	Orient
		01110	* Reserved Codes
		through	*
		11111	*

WORD: D01-01 (continued)

Note 3:

BINARY	WAYPOINT	BINARY	WAYPOINT	BINARY	MARKPOINT
0000	0	0101	5	1010	A
0001	1	0110	6	1011	B
0010	2	0111	7	1100	C
0011	3	1000	8	1101	D
0100	4	1001	9	1110	E
				1111	F

Note 4: A logic "1" shall indicate that the Waypoint/Markpoint identified by bits 7 through 10 is the selected Steerpoint. This bit will be held to logic "1" until I06/I08-22 bits 6 through 9 agree with the selected Steerpoint.

Note 5: A logic "1" shall indicate that the D01 message is invalid. The INU will not process the D01 message.

SUBADDRESS; 11010(T/R) WORD: D01-02

Signal Name - CDU Control Word 2

DATA BIT	DESCRIPTION
1	Fix Freeze Flag (See Note 1)
2	Fix Enter Flag (See Note 1)
3	Mark Flag (See Note 1)
4	Clear Flag (See Note 1)
5	Data Ready Flag (See Note 2)
6	MSB } Inserted Data ID Code (See Note 3)
7	*
8	*
9	*
10	LSB
11	Manual/Automatic Update (See Note 4)
12	Magnetic Variation Flag (See Note 5)
13	Digital Select Flag (See Note 6)
14	Grid Mode Flag (See Note 7)
15	Steering Mode Code (See Note 8)
16	Logic "0"

Note 1: This D01-02 bit shall be set to logic "1" when the indicated INU operation is to be activated. When this D01-02 flag bit is set, the INU shall respond with a logic "1" set in the corresponding bit of the I06/I08-22 word. Subsequent to receipt of a logic "1" in the corresponding I06/I08-22 bit, this D01-02 bit shall be reset to logic "0". Reset of the corresponding I06/I08-22 Flag Acknowledge bit shall be performed only after the corresponding D01-02 bit is reset to logic "0" and shall indicate INU processing complete and the availability of the INU to perform the same function again.

Note 2: This D01-02 bit is set to logic "1" whenever new data is to be inserted into the INU and the appropriate code has been defined for bits 6 through 10 of D01-02. All defined Inserted Data ID Codes require the Data Ready Flag and appropriate words from D01-03 through D01-07 to be set. While the Data Ready Flag is set, the D01 data shall not change. This bit shall be reset either upon receipt of the Data Ready Flag acknowledge in I06/I08-22 or the I06/I08-22 Illegal Command bit 14. After the I06/I08-22 Data Ready Flag acknowledge has been reset or upon receipt of the I06/I08-22 Illegal Command bit, the INU is available to receive new inserted data (see I06/I08-22 Notes 2 and 3).

WORD: D01-02 (continued)

Note 3:

BINARY	INSERTED DATA
00000	Present Position in Latitude/Longitude
00001	Present Position in UTM (plus spheroid)
00010	True Heading (BATH Entry)
00011	Magnetic Variation
00100	Selected Magnetic Course to Steerpoint (G/C Steering)
00101	Waypoint/Markpoint in Latitude/Longitude
00110	Waypoint/Markpoint in UTM (plus spheroid)
00111	Convergence Factor
01000	Miscellaneous Parameter Read
01001	Miscellaneous Parameter Insert
01010	Magnetic Heading (BATH Entry)
01011	Selected Magnetic Course (Selected Course Steering)
01100	Orient Command/Data Insert
01101 through 11111	* Reserved Codes

Note 4: This bit is used in conjunction with the Automatic, Semi-Automatic and Manual update modes. Automatic updates supersede and cancel any pending Semi-Automatic or Manual updates. The Semi-Automatic and Manual update modes are mutually exclusive. The Semi-Automatic mode is active upon receipt of an F02 Correction Vector while the INU is in the Auxiliary Fix mode (Function Select Code 00110). The Manual update mode is active in the Overfly Fix mode (Function Select Code 00101) upon receipt of either the FIX FREEZE (D01-02 bit 1 = 1) or DESIGNATE discrete. Once activated, the Semi-Automatic and Manual update modes remain pending. If the mode is exited without an accept (FIX ENTER) or reject (CLEAR) decision, the mode must be re-entered in order to accept or reject a pending update. Entry into the Semi-Automatic mode causes the position error deltas to be computed based upon the first F02 received in the mode in which F02-01 bit 2 is set to a logic "1". Receipt of the first and all subsequent F02 messages will be acknowledged with the Control Vector Acknowledge bit 8 in I06/I08-01, and I01-01. However these subsequent F02 messages will be inhibited from causing new position error deltas to be computed until the pending Semi-Automatic update is accepted or rejected. If the Auxiliary Fix mode is entered while a previous Semi-Automatic update in pending, the position error deltas from the pending update are active until accepted or rejected. Receipt of Manual update commands while the Manual update mode is pending shall always terminate the pending update and activate the new update.

a. Automatic - When operative, this mode updates the INU from the F02 Correction Vector message without intervention from the operator. The related bit logic is:

(1) D01-01 bits 2 through 6
  - set to Air Align logic code 00011
(2) F02-01 bit 2 - set to logic "1"
(3) D01-02 bit 11 - set to logic "1"
(4) D01-02 bits 1, 2 & 4 - set to logic "0"

b. Semi-Automatic - When operative, this mode provides for automatic input of update data from the F02 Correction Vector message with operator intervention required to either accept or reject the update. Position data only shall be used in this update mode regardless of whether other data is contained in the F02 message. The related bit logic is:

(1) D01-01 bits 2 through 6
- set to Auxiliary Fix logic code 00110
(2) F02-01 bit 2 - set to logic "1"
(3) D01-02 bit 11 - set to logic "0"
(4) D01-02 bit 1 - set to logic "0"
(5) D01-02 bit 2 - set to logic "1" if update is desired
(6) D01-02 bit 4 - set to logic "1" if update is not desired

c. Manual - This mode is used to update the INU by overflying a known position which has been inserted via the CDU or an external computer. Operator intervention via the CDU shall be required to either accept or reject the update. The related bit logic is:

(1) D01-01 bits 2 through 6
- set to Overfly Fix logic code 00101
(2) D01-02 bit 11 - set to logic "0"
(3) D01-02 bit 1 - set to logic "1"
(4) D01-02 bit 2 - set to logic "1" if update is desired
(5) D01-02 bit 4 - set to logic "1" if update is not desired

Note 5: The Magnetic Variation Flag is set to a logic "1" to command the INU to use entered magnetic variation, rather than computed magnetic variation in all INU computations involving magnetic variation. Logic "0" commands the INU to use computed magnetic variation in all INU computations involving magnetic variation.

Note 6: The Digital Select Flag set to logic "1" causes digitally inserted Selected Magnetic Course i.e., Inserted Data ID Code 00100 or 01011 depending on the Steering Mode Code, to be used in lieu of analog (HSI) selected course (see I06/I08-01, Note 12). If the bit is set to logic "0", the analog selected course input is used.

Note 7: This bit is set to logic "1" to place the INU in the Grid Mode in which all INU magnetic heading outputs, both analog and digital, are replaced with computed grid heading. Logic "0" is the normal magnetic heading mode (see I06/I08-01, Note 13).

Note 8: Logic "0" for Great Circle Steering mode. Logic "1" for Selected Course Steering mode.

SUBADDRESS: 11010(T/R) WORD D01-03; D01-04; D01-05; D01-06; D01-07
Signal Name - CDU Inserted Data Words

DATA BIT	DESCRIPTION
1-16	(See Remarks)

REMARKS: The format for each of the five data words shall be defined by the Inserted Data ID Code in bits 6 through 10 of word D01-02. For quantities which do not require all five words to express their values, the unused words shall be sent as all logic "0"s. Table VI-8a indicates which words are unused for a given quantity.

D01 WORD USAGE FORMAT I:
INSERTED PRESENT POSITION LATITUDE/LONGITUDE

Data ID Code: 00000 (See D01-02) WORD: D01-03 (MSP); D01-04 (LSP)
Signal Name - Latitude (pi rad)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (0.5)	18-31	*
3-16	*	32	LSB (4.65661E-10)

REMARKS: MSP = Most Significant Part; LSP = Least Significant Part.

Data ID CODE: 00000 (See D01-02) WORD: D01-05 (MSP); D01-06 (LSP)
Signal Name - Longitude (pi rad)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (0.5)	18-31	*
3-16	*	32	LSB (4.65661E-10)

D01 WORD USAGE FORMAT II:
INSERTED POSITION UTM & SPHEROID

Data ID Code: 00001 (See D01-02) WORD: D01-03
Signal Name - Spheroid/UTM Grid Zone

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Code for Spheroid Model (See Notes 1 and 3)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Zone (MSC) (See Note 2)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

REMARKS: MSC = Most Significant Character.

Note 1:

BINARY	ASCII	MODEL
0110000	0	International
0110001	1	Clark 1866
0110010	2	Clark 1880
0110011	3	Everest
0110100	4	Bessel
0110101	5	Australian National/South American
0110110	6	Airy
0110111	7	Reserved
0111000	8	Reserved
0111001	9	Reserved
1000001	A	WGS-72
1000010	B	WGS-84

Note 2: The order of characters designating the UTM Grid Zone is column first and then row.

Note 3: Default is WGS-84.

D01 WORD USAGE FORMAT II:
INSERTED POSITION UTM & SPHEROID (continued)

Data ID Code: 00001 (See D01-02) WORD: D01-04
Signal Name - UTM Grid Zone

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Coded UTM Grid Zone (2nd LSC)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Zone (LSC)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

Data ID Code: 00001 (See D01-02) WORD: D01-05
Signal Name - 100,000 Meter UTM Grid Area

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Coded UTM Grid Area (MSC) (See Remarks)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Area (LSC)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

REMARKS: The order of the characters designating the 100,000 Meter UTM Grid Area is column first and then row.

D01 WORD USAGE FORMAT II: INSERTED POSITION UTM & SPHEROID (continued)

Data ID Code: 00001 (See D01-02) WORD: D01-06
Signal Name - UTM Easting (m)

DATA BIT	DESCRIPTION	
1	MSB (65,536.0)	UTM Easting (See Remarks)
2-15	*	
16	LSB (2.0)	

REMARKS: Maximum value shall not exceed 99,998.0 meters (m).

Data ID Code: 00001 (See D01-02) WORD: D01-07
Signal Name - UTM Northing (m)

DATA BIT	DESCRIPTION	
1	MSB (65,536.0)	UTM Northing (See Remarks)
2-15	*	
16	LSB (2.0)	

REMARKS: Maximum value shall not exceed 99,998.0 meters.

FORMAT III: INSERTED TRUE HEADING (BATH ENTRY)

Data ID Code: 00010 (See D01-02) WORD: D01-03
Signal Name - True Heading (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

FORMAT IV: INSERTED MAGNETIC VARIATION

Data ID Code: 00011 (See D01-02) WORD: D01-03
Signal Name - Magnetic Variation (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

FORMAT V:
INSERTED SELECTED MAGNETIC COURSE TO STEERPOINT

Data ID Code: 00100 (See D01-02) WORD: D01-03
Signal Name - Magnetic Course to Steerpoint (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

FORMAT VI:
INSERTED WAYPOINT/MARKPOINT LATITUDE/LONGITUDE

Data ID Code: 00101 (See D01-02) WORD: D01-03 (MSP); D01-04 (LSP)
Signal Name - Latitude (pi rad)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (0.5)	18-31	*
3-16	*	32	LSB (4.65661E-10)

Data ID Code: 00101 (See D01-02) WORD: D01-05 (MSP); D01-06 (LSP)
Signal Name - Longitude (pi rad)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (0.5)	18-31	*
3-16	*	32	LSB (4.65661E-10)

FORMAT VII:
INSERTED WAYPOINT/MARKPOINT UTM & SPHEROID

Data ID Code: 00110 (See D01-02) WORD: D01-03
Signal Name - Spheroid/UTM Grid Zone

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Code for Spheroid Model (See Notes 1 and 3)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Zone (MSC) (See Note 2)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

Note 1:

BINARY	ASCII	MODEL
0110000	0	International
0110001	1	Clark 1866
0110010	2	Clark 1880
0110011	3	Everest
0110100	4	Bessel
0110101	5	Australian National/South American
0110110	6	Airy
0110111	7	Reserved
0111000	8	Reserved
0111001	9	Reserved
1000001	A	WGS-72
1000010	B	WGS-84

Note 2: The order of the characters designating the UTM Grid Zone is column first and then row.

Note 3: Default is WGS-84.

FORMAT VII:
INSERTED WAYPOINT/MARKPOINT UTM & SPHEROID (Continued)

Data ID Code: 00110 (See D01-02) WORD: D01-04
Signal Name - UTM Grid Zone

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Coded UTM Grid Zone (2nd LSC)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Zone (LSC)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

Data ID Code: 00110 (See D01-02) WORD: D01-05
Signal Name - 100,000 Meter UTM Grid Area

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Coded UTM Grid Area (MSC) (See Remarks)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Area (LSC)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

REMARKS: The order of the characters designating the 100,000 meter UTM Grid Area is column first and then row.

FORMAT VII: INSERTED WAYPOINT/MARKPOINT UTM & SPHEROID (Continued)

Data ID Code: 00110 (See D01-02) WORD: D01-06
Signal Name - UTM Easting (m)

DATA BIT	DESCRIPTION	
1	MSB (65,536.0)	UTM Easting (See Remarks)
2-15	*	
16	LSB (2.0)	

REMARKS: Maximum value shall not exceed 99,998.0 meters.

Data ID Code: 00110 (See D01-02) WORD: D01-07
Signal Name - UTM Northing (m)

DATA BIT	DESCRIPTION	
1	MSB (65,536.0)	UTM Northing (See Remarks)
2-15	*	
16	LSB (2.0)	

REMARKS: Maximum value shall not exceed 99,998.0 meters.

FORMAT VIII: INSERTED CONVERGENCE FACTOR

Data ID Code: 00111 (See D01-02) WORD: D01-03
Signal Name - Convergence

DATA BIT	DESCRIPTION
1	MSB (1.0)
2-15	*
16	LSB (3.05176E-05)

FORMAT IX: MISCELLANEOUS PARAMETER READ

Data ID Code: 01000 (See D01-02) WORD: D01-03
Signal Name - Miscellaneous Parameter Code

DATA BIT	DESCRIPTION	
1	MSB	Binary Code (See Remarks)
2-15	*	
16	LSB	

REMARKS: Decimal equivalent of codes are defined as follows:

TABLE OF MISCELLANEOUS PARAMETERS					ALTER-NATE
NO.	DEFINITION	UNITS	RANGE	FORMATS	
0	Manufacturer's ID Code	Special	Constant	"bbbbbC"	
1	BITE History (BITE status for previous operation, update for each INU turn-on - See Note 1)	Decimal	0-99999	"bDDDDD"	
2	BITE Status (BITE status for present operation, update for each INU turn-on - See Note 1)	Decimal	0-99999	"bDDDDD"	
3	Initialization Latitude	Deg-Min	± 90 deg 00.0'	"±bDDMMT"	
4	Initialization Longitude	Deg-Min	±180 deg 00.0'	"±DDDMMT"	
5	Present Pure Inertial Latitude	Deg-Min	± 90 deg 00.0'	"±bDDMMT"	
6	Present Pure Inertial Longitude	Deg-Min	±180 deg 00.0'	"±DDDMMT"	
7	INU OFP ID Number	Special	Constant	"CCCCbC"	
8	Current MUX Controller and Time INU Last Assumed Control	Binary Minutes	0(RT),1(BBC) 0-999.9	"BbMMMT"	
9	Delta Position North (Update #1)	Nmi	±327.7	"±bbNNNT"	
10	Delta Position East (Update #1)	Nmi	±327.7	"±bbNNNT"	
11	Time in NAV at Update #1	Minutes	0-9999.9	"bMMMMT"	
12	Delta Position North (Update #2)	Nmi	±327.7	"±bbNNNT"	
13	Delta Position East (Update #2)	Nmi	±327.7	"±bbNNNT"	
14	Time in NAV at Update #2	Minutes	0-9999.9	"bMMMMT"	

Note 1: MISC words 1 and 2 are summaries of the INU BIT status.
MISC word 1 is resettable at the depot level.

TABLE OF MISCELLANEOUS PARAMETERS					ALTER-NATE
NO.	DEFINITION	UNITS	RANGE	FORMATS	
15	Delta Position North (Update #3)	Nmi	±327.7	"±bbNNNT"	
16	Delta Position East (Update #3)	Nmi	±327.7	"±bbNNNT"	
17	Time in NAV at Update #3	Minutes	0-9999.9	"bMMMMT"	
18	Manually-Entered True Airspeed	Knots	0-2047.8	"bKKKKT"	
19	Mission Radial Error Rate (RER) **(includes EIA alignments)**	Nmi/hr	0-9.9	"RERN.T"	"RERbNA"
20	CUM CEP Update (GC) **(includes EIA alignments)**	Decimals Nmi/hr	1-8 0-9.9	"DbbN.T"	"SQUAWK"
21	Last Computed Value of Misc #20 **(includes EIA alignments)**	Decimal Nmi/hr	1-8 0-9.9	"DbbN.T"	
22	Terminal Base Lat Used for Last RER	Deg-Min	± 90deg 00.0'	**"±bDDMMT"**	
23	Terminal Base Long Used for Last RER	Deg-Min	±180deg 00.0'	**"±DDDMMT"**	
24	Pure Inertial Lat Used for Last RER	Deg-Min	± 90deg 00.0'	**"±bDDMMT"**	
25	Pure Inertial Long Used for Last RER	Deg-Min	±180deg 00.0'	**"±DDDMMT"**	
26 thru 33	Last 8 Mission RER's(old) (For GC Alignments) **(Previous Mission RER-GC)** **(includes EIA alignments)**	Nmi/hr	0-9.9	**"RERN.T"**	
34	**INU On/Off Cycles**	Integer	0-65536	**"bIIIII"**	
35	Misc Location of Last Computed RER	Integer	0-65536	**"bbbbII"**	
36	Orient Status Word	Alpha-numeric	-	**"AAAAAA"**	

VI-9 - Miscellaneous Parameters (continued)

TABLE OF MISCELLANEOUS PARAMETERS					ALTER-NATE
NO.	DEFINITION	UNITS	RANGE	FORMATS	
37	Roll Boresight Angle	Deg-Min-Sec	± 45deg 00'00"	"±DDMMSS"	"+bbbbbb"
38	Pitch Boresight Angle	Deg-Min-Sec	± 45deg 00'00"	"±DDMMSS"	"+bbbbbb"
39	Yaw Boresight Angle	Deg-Min-Sec	± 45deg 00'00"	"±DDMMSS"	"+bbbbbb"
40 thru 59	RESERVED				
60	Terminal Address	Binary	1-11110	"bBBBBB"	
61	Baro-Inertial Altitude	Feet	-1500 to +80000	"±bFFFFF"	
62	Align Events	**Binary**	**0-100000**	**"BBBBBB"**	
63	Time in Align Mode	Minutes	0-9999.9	"MMMM.T"	
64	Nav Events	**Binary**	**0-100000**	**"BBBBBB"**	
65	Time in Nav Mode	Minutes	0-9999.9	"MMMM.T"	
66 thru 98	INU Standard Functions TBD by Procuring Activity				
99	NARF Disable	Binary	0 or 1	"bbbbbB"	
100	Time In NARF	Minutes	0-9999.9	"MMMM.T"	
101 thru 131	Contractor Unique Functions TBD by Contractor				
132	**RESERVED**				
133	**RESERVED**				
134 & Up	Contractor Unique Functions TBD by Contractor				

FORMAT X:
MISCELLANEOUS PARAMETER INSERT

Data ID Code: 01001 (See D01-02) WORD: D01-03
Signal Name - Miscellaneous Parameter Code

DATA BIT	DESCRIPTION	
1	MSB	Binary Code (See Remarks)
2-15	*	
16	LSB	

REMARKS: Decimal equivalent of codes are defined as follows:

DECIMAL EQUIVALENT	MISC PARAMETER INSERT DEFINITION
0 thru 17	Shall not be used
18	Manually entered TAS
19 thru 20	Shall not be used
21	Cumulative CEP/Mission RER history clear
22 thru 65	Shall not be used
66 thru 98	INU Standard Functions - TBD (by Procuring Activity)
99	NARF Disable
100	Shall not be used
101 thru 131	Contractor Unique Functions - TBD (by Contractor)
132, 133	Shall not be used
134 & up	Contractor Unique Functions - TBD (by Contractor)

Data ID Code: 01001 (See D01-02) WORD: D01-04
Signal Name - Parameter Word 1

DATA BIT	DESCRIPTION	
1	Sign Bit	
2	MSB	ASCII Parameter (MSC)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Parameter (5th LSC)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

REMARKS: MSC = Most Significant Character; LSC = Least Significant Character. Non-printing and lower case characters shall not be used except that an ASCII coded blank is permissible.

FORMAT X:
MISCELLANEOUS PARAMETER INSERT (Continued)

Data ID Code: 01001 (See D01-02) WORD: D01-05
Signal Name - Parameter Word 2

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Parameter (4th LSC)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Parameter (3rd LSC)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

REMARKS: Non-printing and lower case characters shall not be used except that an ASCII coded blank is permissible.

Data ID Code: 01001 (See D01-02) WORD: D01-06
Signal Name - Parameter Word 3

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Parameter (2nd LSC)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Parameter (LSC)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

REMARKS: Non-printing and lower case characters shall not be used except that an ASCII coded blank is permissible.

FORMAT XI:
INSERTED MAGNETIC HEADING (BATH ENTRY)

Data ID Code: 01010 (See D01-02) WORD: D01-03
Signal Name - Magnetic Heading (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

FORMAT XII:
INSERTED SELECTED MAGNETIC COURSE

Data ID Code: 01011 (See D01-02) WORD: D01-03
Signal Name - Selected Magnetic Course (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

FORMAT XIII:
ORIENT CONTROL WORD

Data ID Code: 01100 (See D01-02) WORD: D01-03
Signal Name - Orient Function

DATA BIT	VALUE	FUNCTION DESCRIPTION	
1-2	00	Orient OFF / Boresight OFF	(Default)
	01	Prohibited	(Note 1)
	10	Orient ON / Boresight OFF	
	11	Orient ON / Boresight ON	
3-5	000	No Entry / RESET Flags	(Default - Note 2)
	001	Data Bus Entry of Basic Orientation	(Note 3)
	010	Data Bus Entry of Boresight Angles	(Note 4)
	011	Function Reserved	(Note 5)
	100	**Function Reserved**	
	101	Clear Stored Basic Orientation	(Note 7)
	110	" " Boresight Angles	(Note 8)
	111	Function Reserved	**(Note 5)**
6	0	Compare Entered Data	
	1	Store Entered Data	
7	0	**Function Reserved**	
8	0	" "	
9	0	" "	
10	0	" "	
11	0	" "	
12	0	" "	
13	0	" "	
14	0	" "	
15	0	" "	
16	0	" "	

Remark: Default values represent functions or conditions which shall be assumed by the INU upon power-up unless otherwise programmed.

WORD: D01-03 Format XIII (continued)

Note 1: This command shall not be permitted. Attempt to program this command shall invoke an "illegal command" error.

Note 2: No data is to be entered in subsequent data words. All previously stored values shall remain unaltered. The Entered Data Compare flag in the Orient Status Word shall be reset to logic 0.

Note 3: This function shall require a basic orientation to be supplied in subsequent data word D01-04.

Note 4: This function requires boresight angles to be supplied in subsequent data words D01-04, D01-05, and D01-06.

Note 5: This function is reserved for future use. Attempt to command this function shall invoke an "illegal command" error.

Note 6: **Deleted**

Note 7: This command shall clear the basic orientation values stored in the Orient Status word to the default basic orientation. This command shall be permitted only when the Orient function is disabled. An attempt to program this command while the Orient function is enabled shall invoke an "illegal command" error.

Note 8: This command shall clear all stored boresight **correction angles** to zero and reset the Boresight Store Complete flag **(bit 10 of the** Orient Status Word) to logic 0. **This command shall be permitted** only when the Boresight function is disabled. **An attempt to** program this command **with the Boresight function enabled shall** invoke an "illegal command" error.

Note 9: **Deleted**

FORMAT XIII:
ORIENT CONTROL WORD (continued)

Data ID Code: 01100 (See D01-02) WORD: D01-04
Signal Name - Basic Orientation

Data Bit	Description
1	MSB Basic Orientation Roll (X_r)
2	LSB " " "
3	MSB Basic Orientation Pitch (Y_r)
4	LSB " " "
5	MSB Basic Orientation Yaw (Z_r)
6	LSB " " "
7-16	Logic "0"

REMARKS: Format to be used for D01-04 shall depend upon whether Basic Orientation or Boresight Angle data entry has been specified in D01-03.

Basic Orientations are coded as follows:

MSB	LSB	Orientation
0	0	0 deg
0	1	90 deg
1	0	180 deg
1	1	270 deg

Data ID Code: 01100 (See D01-02) WORD: D01-04
Signal Name - Roll Boresight Correction Angle (deg)

Data Bit	Description
1	Sign Bit
2	MSB (45.0)
3-15	*
16	LSB (2.74658E-03)

REMARKS: Format to be used for D01-04 shall depend upon whether Basic Orientation or Boresight Angle data entry has been specified in D01-03.

FORMAT XIII:
ORIENT CONTROL WORD (continued)

Data ID Code: 01100 (See D01-02) WORD: D01-05
Signal Name - Pitch Boresight Correction Angle (deg)

Data Bit	Description
1	Sign Bit
2	MSB (45.0)
3-15	*
16	LSB (2.74658E-03)

REMARKS: All bits in this word shall be set to 0 unless Boresight Angle entry has been specified in D01-03.

Data ID Code: 01100 (See D01-02) WORD: D01-06
Signal Name - Yaw Boresight Correction Angle (deg)

Data Bit	Description
1	Sign Bit
2	MSB (45.0)
3-15	*
16	LSB (2.74658E-03)

REMARKS: All bits in this word shall be set to 0 unless Boresight Angle entry has been specified in D01-03.

BLOCK ID: I06/I08 Refresh Rate - Shown for each word
Transmit Rate - 12.5Hz (I06); 50Hz (I08)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-01 Refresh Rate - 50Hz
Signal Name - INU Control Word 1

DATA BIT	DESCRIPTION	
1	Analog Attitude Data Fail	(Note 1)
2	Any Navigation Data Fail	(Notes 1 and 2)
3	Degraded Navigation	(Note 3)
4	Navigation Data Unavailable	(Note 4)
5	Digital Attitude Data Fail	(Note 1)
6	Degraded NAV Ready	(Note 5)
7	Attitude Ready	(Note 6)
8	Control Vector Acknowledge	(Note 7)
9	Altitude Loop Bit	(Note 8)
10	INU in Initiated Bit	(Note 9)
11	Degraded Align Complete	(Note 10)
12	In Manual Magnetic Variation	(Note 11)
13	Digital Select	(Note 12)
14	In Grid Mode	(Note 13)
15	CDU Fail	(Note 14)
16	NAV Ready	(Note 15)

REMARKS: A logic "1" shall indicate that the referenced condition is true. NAV data is defined to be INU computed position, velocity, and acceleration data exclusive of ATTITUDE data, where attitude data is defined to be platform azimuth (not true/magnetic heading), roll, and pitch. Reference Time-lines Figures 3.2.1.10-1 thru 3.2.1.10-6.

Note 1: Applicable to failures only (not invalid data).

Note 2: Applicable to digital nav data only, not attitude data.

Note 3: The INU is in the NAV mode and degraded performance is expected as a result of a detected failure, or a degraded performance alignment was performed in accordance with Table I. This bit is the complement of F02-01 bit 3 when in the AIR ALIGN mode.

Note 4: The INU is not in the NAVIGATE, AIR ALIGN, OVERFLY or AUXILIARY mode.

Note 5: NAV mode may be entered with at least degraded navigation performance in accordance with Table I.

Note 6: Usable ATTITUDE data of $\leq$ 1 degree of uncertainty is available. The NAV mode may not be entered unless the filter mode bit (F02-01, bit 2) is set.

Note 7: Acknowledge receipt of all F02 correction vectors in all system modes. In addition, when used in the generalized CDU AIR ALIGN mode, this bit provides feedback that a block F02 has been received and applied per the description on sheet 2 of the block F02 definition.

Note 8: Baro-Inertial data is invalid. CADC invalid (I06/I08-22 bit 16) in the align mode will set this bit immediately. CADC invalid in the navigate mode will set this bit after five seconds of continuous CADC fail.

Note 9: The INU is in the initiated Built-In-Test (BIT) mode. This bit shall be reset to logic "0" at the completion of initiated BIT.

Note 10: Alignment to previously stored "inertial display" position is complete. NAV mode may be entered with unspecified performance.

Note 11: Manually entered magnetic variation is used in the computation of all magnetic related outputs.

Note 12: Digital Select Flag Acknowledge. This bit shall be set to a logic "1" in response to receiving a logic "1" in a corresponding bit of D01-02. Subsequent to the INU receiving a logic "0" in the corresponding bit of D01-02, the INU shall reset this I06/I08-01 bit to logic "0". Digitally entered selected magnetic course is used in lieu of analog (HSI) selected course.

Note 13: Grid Mode Flag Acknowledge. This bit shall be set to a logic "1" in response to receiving a logic "1" in a corresponding bit of D01-02. Subsequent to the INU receiving a logic "0" in the corresponding bit of D01-02, the INU shall reset this I06/I08-01 bit to logic "0". INU magnetic heading outputs (digital and analog) shall be replaced by grid heading in this mode.

Note 14: Echo of D01-01 bit 1 CDU fault flag.

Note 15: NAV mode may be entered with full specified performance. This bit shall also be set in the CDU selectable "CAL" mode to denote when the navigate mode may be entered.

SUBADDRESS: 11001 (T/R) WORD: I06/I08-02 Refresh Rate = 50Hz
Signal Name - INU Control Word 2 (Time Tag) (Micro seconds)

DATA BIT	DESCRIPTION
1	MSB (2,097,152.0)
2-15	*
16	LSB (64.0)

REMARKS: This word shall be updated continuously after power-up/system initialization (approximately 5 seconds). **This time tag is referenced to the beginning of the velocity computation cycle.**

SUBADDRESS: 11001 (T/R) WORD: I06/I08-03 (MSP) Refresh Rate = 50Hz
I06/I08-04 (LSP) Refresh Rate = 50Hz

Signal Name - X Velocity (fps)

DATA BIT	DESCRIPTION (MSP)		DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (4096)	18-31	*
3-16	*	32	LSB (3.81470E-06)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-05 (MSP) Refresh Rate = 50Hz
I06/I08-06 (LSP) Refresh Rate = 50Hz

Signal Name - Y Velocity (fps)

DATA BIT	DESCRIPTION (MSP)		DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (4096)	18-31	*
3-16	*	32	LSB (3.81470E-06)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-07 (MSP) Refresh Rate = 50Hz
I06/I08-08 (LSP) Refresh Rate = 50Hz

Signal Name - Z Velocity (fps)

DATA BIT	DESCRIPTION (MSP)		DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (4096)	18-31	*
3-16	*	32	LSB (3.81470E-06)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-09 Refresh Rate = 50Hz
Signal Name - Platform Azimuth (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-10 Refresh Rate = 50Hz
Signal Name - Roll (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-11 Refresh Rate = 50Hz
Signal Name - Pitch (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-12 Refresh Rate = 50Hz
Signal Name - Present True Heading (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-13 Refresh Rate = 10Hz
Signal Name - Present Magnetic Heading (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-14 Refresh Rate = 2.5Hz
Signal Name - Great Circle Steering Error (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-15 Refresh Rate = 2.5Hz
Signal Name - Computed Course Deviation (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-16 Refresh Rate = 5Hz
Signal Name - Time to Steerpoint (seconds)

DATA BIT	DESCRIPTION
1	MSB (32,768.0)
2-15	*
16	LSB (1.0)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-17 Refresh Rate = 2.5Hz
Signal Name - Distance to Steerpoint (nmi)

DATA BIT	DESCRIPTION
1	MSB (3,276.8)
2-15	*
16	LSB (0.1)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-18 Refresh Rate = 5Hz
Signal Name - Relative Bearing to Steerpoint (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-19 Refresh Rate = 5Hz
Signal Name - Relative Bearing to nth Waypoint/Markpoint (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-20 Refresh Rate = 2.5Hz
Signal Name - Time to nth Waypoint/Markpoint (seconds)

DATA BIT	DESCRIPTION
1	MSB (32,768.0)
2-15	*
16	LSB (1.0)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-21 Refresh Rate = 2.5Hz
Signal Name - Distance to nth Waypoint/Markpoint (nmi)

DATA BIT	DESCRIPTION
1	MSB (3,276.8)
2-15	*
16	LSB (0.1)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-22 Refresh Rate = 50Hz
Signal Name - INU Control Word 3

DATA BIT	DESCRIPTION	
1	Fix Freeze Flag Acknowledge	(See Note 1)
2	Fix Enter Flag Acknowledge	(See Note 1)
3	Mark Flag Acknowledge	(See Note 1)
4	Clear Flag Acknowledge	(See Note 1)
5	Data Ready Flag Acknowledge	(See Note 2)
6	MSB	
7	* Present Steerpoint Code	
8	*	
9	LSB	
10	MSB	
11	* Present Waypoint/Markpoint Code	
12	*	
13	LSB	
14	Illegal Command	(See Note 3)
15	Position Error Valid	(See Note 4)
16	CADC Invalid	(See Note 5)

Note 1: This I06-22 bit shall be set to logic "1" in response to receiving a logic "1" in the corresponding bit of D01-02. The I06-22 bit being set to logic "1" shall cause the D01-02 bit to be reset to logic "0". Transmission of the Flag Acknowledge shall mean the INU has received the flag in D01-02 and is processing the corresponding INU function. When INU processing is completed and all corresponding outputs in I06 and I07 have been updated to reflect the function activated, and the D01 Data Ready Flag has been reset to logic "0", the Flag Acknowledge shall be reset to logic "0". Upon transmission of a reset Flag Acknowledge, the INU shall be available to perform the same function again.

Note 2: INU transmission of the Data Ready Flag Acknowledge (logic "1") shall mean the INU has received the D01-02 Data Ready Flag and is processing the D01 data. The D01-02 Data Ready Flag shall be reset to logic "0" upon receipt of the Data Ready Flag Acknowledge (logic "1"). When the INU processing is completed and all corresponding outputs in I06 and I07 have been updated to reflect the new inserted quantity, and the D01 Data Ready Flag has been reset to logic "0", the Flag Acknowledge shall be reset to logic "0". Upon transmission of a reset Flag Acknowledge, the INU shall be available to receive new inserted data. Data Bits 5 and 14 are mutually exclusive events.

Note 3: Set illegal command bit for illegal mode transition. A logic "1" shall indicate that the INU cannot comply with the D01 inserted command. If a miscellaneous parameter is undefined, a Miscellaneous Read or Miscellaneous Insert message encoded for that parameter shall cause the Illegal Command bit to be set. If a miscellaneous parameter is a read only quantity, transmission of a Miscellaneous Insert message encoded for that parameter shall cause the Illegal Command bit to be set. INU transmission of the Illegal Command bit set to logic "1" shall cause the D01-02 Data Ready Flag to be reset to logic "0". Subsequent to the INU receiving a reset Data Ready Flag bit, the INU shall reset the Illegal Command Bit to logic "0".

Note 4: The Position Error Valid bit shall be set to a logic "1" whenever either the Semi-Automatic or Manual Update modes are active and the position error deltas in I07-28 and I07-29 are valid. Subsequent to deactivation of the update mode, this bit shall be set to logic "0".

Note 5: As a minimum, CADC Invalid shall be set to logic "1" if C01 is not received at least once per second or if the C01-01 bit 1 Pressure Altitude Valid is set to logic "0". Subsequent to receiving the Pressure Altitude Valid bit set to logic "1" in C01-01 or C03-01, this bit shall be set to logic "0".

SUBADDRESS: 11001 (T/R) WORD: I06/I08-23 (MSP) Refresh Rate = 2.5Hz
I06/I08-24 (LSP) Refresh Rate = 2.5Hz

Signal Name - nth Waypoint/Markpoint Latitude (pi rad)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (0.5)	18-31	*
3-16	*	32	LSB (4.65661E-10

SUBADDRESS: 11001 (T/R) WORD: I06/I08-25 (MSP) Refresh Rate = 2.5Hz
I06/I08-26 (LSP) Refresh Rate = 2.5Hz

Signal Name - nth Waypoint/Markpoint Longitude (pi rad)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (0.5)	18-31	*
3-16	*	32	LSB (4.65661E-10)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-27 Refresh Rate = 5Hz
Signal Name - Selected Magnetic Course to Steerpoint (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-28 Refresh Rate = 5Hz
Signal Name - Selected Magnetic Course (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-29 Refresh Rate - 5Hz
Signal Name - Magnetic Heading to nth Waypoint/Markpoint (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06/I08-30 Refresh Rate - 20Hz
Signal Name - True Air Speed (knots)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2048)
3-15	*
16	LSB (0.125)

Note: Negative velocities will be displayed in a 2's compliment format.

SUBADDRESS: 11001 (T/R) WORD: I06/I08-31 Refresh Rate - 5Hz
Signal Name - Present Magnetic Ground Track (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11001 (T/R) WORD: I06-32 Refresh Rate - 5Hz
Signal Name - Present Drift Angle (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit (See Note 1)
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

Note 1: Sign is positive when drift is to the right of the Aircraft Centerline (requires a left heading correction).

BLOCK ID: I07 Refresh Rate = 2.5Hz Transmission Rate = 12.5Hz.
SUBADDRESS: 11011 (T/R) WORD: I07-01
Signal Name - nth Waypoint/Markpoint Spheroid/UTM Grid Zone

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Code for Spheroid Model (See Notes 1 and 3)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Zone (See Note 2)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

Note 1:

BINARY	ASCII	MODEL
0110000	0	International
0110001	1	Clark 1866
0110010	2	Clark 1880
0110011	3	Everest
0110100	4	Bessel
0110101	5	Australian National/South American
0110110	6	Airy
0110111	7	Reserved
0111000	8	Reserved
0111001	9	Reserved
1000001	A	WGS-72
1000010	B	WGS-84

Note 2: The order of characters designating the UTM Grid Zone is column first and then row.

Note 3: Default is WGS-84.

SUBADDRESS: 11011 (T/R) WORD: I07-02

Signal Name - nth Waypoint/Markpoint UTM Grid Zone

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Coded UTM Grid Zone (2nd LSC)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Zone (LSC)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

SUBADDRESS: 11011 (T/R) WORD: I07-03

Signal Name - nth Waypoint/Markpoint 100,000 Meter UTM Grid Area

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Coded UTM Grid Area (See Remarks)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Area (LSC)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

REMARKS: The order of the characters designating the 100,000 Meter UTM Grid Area is column first and then row.

SUBADDRESS: 11011 (T/R) WORD: I07-04

Signal Name - nth Waypoint/Markpoint UTM Easting (m)

DATA BIT	DESCRIPTION	
1	MSB (65,536.0)	UTM Easting (See Remarks)
2-15	*	
16	LSB (2.0)	

REMARKS: Maximum value shall not exceed 99,998.0 meters.

SUBADDRESS: 11011 (T/R) WORD: I07-05

Signal Name - nth Waypoint/Markpoint UTM Northing (m)

DATA BIT	DESCRIPTION	
1	MSB (65,536.0)	UTM Northing (See Remarks)
2-15	*	
16	LSB (2.0)	

REMARKS: Maximum value shall not exceed 99,998.0 meters.

SUBADDRESS: 11011 (T/R) WORD: I07-06 (MSP); I07-07 (LSP)

Signal Name - Present Position Latitude (pi rad)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (0.5)	18-31	*
3-16	*	32	LSB (4.65661E-10

SUBADDRESS: 11011 (T/R) WORD: I07-08 (MSP); I07-09 (LSP)

Signal Name - Present Position Longitude (pi rad)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (0.5)	18-31	*
3-16	*	32	LSB (4.65661E-10

SUBADDRESS: 11011 (T/R) WORD: I07-10

Signal Name - Present Position Spheroid/UTM Grid Zone

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Code for Spheroid Model (See Notes 1 and 3)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Zone (MSC) (See Note 2)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

Note 1:

BINARY	ASCII	MODEL
0110000	0	International
0110001	1	Clark 1866
0110010	2	Clark 1880
0110011	3	Everest
0110100	4	Bessel
0110101	5	Australian National/South American
0110110	6	Airy
0110111	7	Reserved
0111000	8	Reserved
0111001	9	Reserved
1000001	A	WGS-72
1000010	B	WGS-84

Note 2: The order of characters designating the UTM Grid Zone is column first and then row.

Note 3: Default is WGS-84.

SUBADDRESS: 11011 (T/R) WORD: I07-11

Signal Name - UTM Grid Zone

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Coded UTM Grid Zone (2nd LSC)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Zone (LSC)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

SUBADDRESS: 11011 (T/R) WORD: I07-12

Signal Name - Present Position 100,000 Meter UTM Grid Area

DATA BIT	DESCRIPTION	
1	Logic "0"	
2	MSB	ASCII Coded UTM Grid Area (MSC) (See Remarks)
3	*	
4	*	
5	*	
6	*	
7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Coded UTM Grid Area (LSC)
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB	

REMARKS: The order of the characters designating the 100,000 meter UTM Grid Area is column first and the row.

SUBADDRESS: 11011 (T/R) WORD: I07-13
Signal Name - Present Position UTM Easting (m)

DATA BIT	DESCRIPTION	
1	MSB (65,536.0)	UTM Easting (See Remarks)
2-15	*	
16	LSB (2.0)	

REMARKS: Maximum value shall not exceed 99,998.0 meters.

SUBADDRESS: 11011 (T/R) WORD: I07-14
Signal Name - Present Position UTM Northing (m)

DATA BIT	DESCRIPTION	
1	MSB (65,536.0)	UTM Northing (See Remarks)
2-15	*	
16	LSB (2.0)	

REMARKS: Maximum value shall not exceed 99,998.0 meters.

SUBADDRESS: 11011 (T/R) WORD: I07-15
Signal Name - Entered True Heading (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11011 (T/R) WORD: I07-16
Signal Name - Entered Magnetic Heading (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11011 (T/R) WORD: I07-17

Signal Name - Entered Magnetic Variation (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-14	*
15	LSB (6.10352E-05)
16	Steering Mode Code (See Remarks)

Remarks: Logic "0" for Great Circle Steering Mode. Logic "1" for Selected Course Steering.

SUBADDRESS: 11011 (T/R) WORD: I07-18

Signal Name - Computed Magnetic Variation (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11011 (T/R) WORD: I07-19

Signal Name - Align Time and Status (seconds)

DATA BIT	DESCRIPTION	
1	MSB	Alignment Status Code (See Note 1)
2	*	
3	*	
4	*	
5	*	
6	LSB	
7	MSB (3072.0)	Alignment Time
8	*	
9	*	
10	*	
11	*	
12	*	
13	*	
14	*	
15	*	
16	LSB (6.0)	

Note 1: The following alignment status codes shall be used for operator information only and shall not imply system performance requirements. When a degraded performance alignment is being performed as a result of failure of the operator to enter present position, the alignment status codes shall alternate at a 1 Hz rate between code 000000 and the code for the expected navigation performance achieved.

BINARY	ALIGNMENT STATUS
000000	Initial Condition
000001	Attitude Available
000010	Attitude and Heading Available
000011	8.0
000100	7.2
000101	6.4
000110	5.6
000111	4.8
001000	4.0
001001	3.2
001010	2.4
001011	1.6
001100	0.8
001101	0.7
001110	0.6
001111	0.5
010000	0.4
010001	0.35
010010	0.30
010011	0.25
010100	0.20
010101	0.15
010110	0.10
010111	0.05

SUBADDRESS: 11011 (T/R) WORD: I07-20

Signal Name - Wind Direction (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11011 (T/R) WORD: I07-21

Signal Name - Wind Velocity/Last Mark Point Code (knots)

DATA BIT	DESCRIPTION	
1	MSB (256.0)	
2-12	*	
13	LSB (0.0625)	
14	MSB	Last Mark Point Code (See Note 1)
15	*	
16	LSB	

Note 1: The location that the last Mark Point was loaded into shall be coded as follows:

BINARY	LOCATION	BINARY	LOCATION
000	No Mark Point	100	Mark Point D
001	Mark Point A	101	Mark Point E
010	Mark Point B	110	Mark Point F
011	Mark Point C		

SUBADDRESS: 11011 (T/R) WORD: I07-22

Signal Name - Present Ground Speed (knots)

DATA BIT	DESCRIPTION
1	MSB (2,048.0)
2-15	*
16	LSB (0.0625)

SUBADDRESS: 11011 (T/R) WORD: I07-23
Signal Name - Present True Ground Track (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05175E-05)

SUBADDRESS: 11011 (T/R) WORD: I07-24
Signal Name - Predicted Ground Speed (knots)

DATA BIT	DESCRIPTION
1	MSB (2,048.0)
2-15	*
16	LSB (0.0625)

SUBADDRESS: 11011 (T/R) WORD: I07-25
Signal Name - Present Convergence Factor in Use

DATA BIT	DESCRIPTION
1	MSB (1.0)
2-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11011 (T/R) WORD: I07-26
Signal Name - Present Grid Heading (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11011 (T/R) WORD: I07-27
Signal Name - Desired Grid Heading (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11011 (T/R) WORD: I07-28

Signal Name - Position Error North (nmi)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (163.84)
3-15	*
16	LSB (0.01)

SUBADDRESS: 11011 (T/R) WORD: I07-29

Signal Name - Position Error East (nmi)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (163.84)
3-15	*
16	LSB (0.01)

REMARKS: These position errors are transmitted whenever either a Semi-Automatic (AUXILIARY) or a Manual (OVERFLY) mode update is pending. Upon acceptance or rejection of an update, the position errors are reset to logic zero. If the deltas are more than 327.68 nmi, an accept command shall result in bit 14 of I06/I08-22 being set to logic "1" in lieu of the deltas being applied to the present "inertial display" position.

SUBADDRESS: 11011 (T/R) WORD: I07-30

Signal Name - INU Miscellaneous Data

DATA BIT	DESCRIPTION	
1	Sign Bit	
2	MSB	ASCII Parameter (MSC)
3-7	*	
8	LSB	
9	Logic "0"	
10	MSB	ASCII Parameter (5th LSC)
11-15	*	
16	LSB	

SUBADDRESS: 11011 (T/R) WORD: I07-31

Signal Name - INU Miscellaneous Data

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB } ASCII Parameter (4th LSC)
3-7	*
8	LSB
9	Logic "0"
10	MSB } ASCII Parameter (3rd LSC)
11-15	*
16	LSB

SUBADDRESS: 11011 (T/R) WORD: I07-32

Signal Name - INU Miscellaneous Data

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB } ASCII Parameter (2nd LSC)
3-7	*
8	LSB
9	Logic "0"
10	MSB } ASCII Parameter (LSC)
11-15	*
16	LSB (See Note 1)

REMARKS: Non-printing and lower case characters shall not be used except that an ASCII coded blank is permissible. In the absence of Miscellaneous Parameter Inserted Data ID codes (Read or Insert), the I07-30 through I07-32 words shall contain the current data corresponding to the last received Miscellaneous Parameter Code (D01-03). The manufacturer's ID Code (LSC) shall be as follows:

Note 1:

BINARY	ASCII	MANUFACTURER	
0110000	0	Kearfott Guidance & Navigation Corp.	(Gimballed Systems)
0110001	1	Litton Guidance Division	(Gimballed Systems)
0110010	2	Rockwell Autonetics Division	(Strapdown Systems)
0110011	3	Litton Guidance Division	(Strapdown Systems)
0110100	4	GM Delco Division	(Strapdown Systems)
0110101	5	Lear Siegler	(Strapdown Systems)
0110110	6	Honeywell	(Strapdown Systems)
0110111	7	Teledyne	(Strapdown Systems)
0111000	8	Raytheon	(Strapdown Systems)
0111001	9	Kearfott Guidance & Navigation Corp.	(Strapdown Systems)

P02	Deleted
F01	Deleted
I02/I03	Deleted

BLOCK ID: F02 Refresh Rate = N/A Transmit Rate = 5 Hz max

F02 - Correction Vector

An external computer shall transmit the following correction vector to the INU as required. The correction vector states are:

a.	CC/INU Mode Word	(F02-01)
b.	CNEXX Correction	(F02-02, 03)
c.	CNEXY Correction	(F02-04, 05)
d.	CNEXZ Correction	(F02-06, 07)
e.	Longitude Correction	(F02-08, 09)
f.	Velocity Correction (X)	(F02-10)
g.	Velocity Correction (Y)	(F02-11)
h.	Tilt Correction (X)	(F02-12)
i.	Tilt Correction (Y)	(F02-13)
j.	X Gyro Bias Correction	(F02-14)
k.	Y Gyro Bias Correction	(F02-15)
l.	Z Gyro Bias Correction	(F02-16)
m.	CNEYX Correction	(F02-17, 18)
n.	CNEYY Correction	(F02-19, 20)
o.	CNEYZ Correction	(F02-21, 22)
p.	Tilt Correction (Z)	(F02-23)
q.	X Accelerometer Bias Correction	(F02-24)
r.	Y Accelerometer Bias Correction	(F02-25)
s.	Z Accelerometer Bias Correction	(F02-26)
t.	Velocity Correction (Z)	(F02-27)
u.	Baro Bias Correction	(F02-28)
v.	Altitude Correction	(F02-29)
w.	2nd CC/INU Mode Word	(F02-30)

When message block F02 is received with the INU in the Auxiliary Fix mode, the "inertial display" position shall be updated consistent with D01-02, Note 4, with corrections contained in states b through e. When the F02 message block is received with the INU in the Automatic Fix mode, the "pure inertial" position shall be updated with corrections contained in states b through e consistent with D01-02, Note 4, and with states f through l as defined below. All corrections to the current value of the INU will be additive corrections (i.e. deltas) that is CURRENT + DELTAS = UPDATED VALUES. The input axes for the gyros and accelerometers are transmitted in the sensor frame Xs, Ys, Zs axes for strapdown systems and in the navigation frame X, Y, Z axes for gimbaled systems. Corrections to the gyros and accelerometers will be applied to these axes. The sign conventions are as follows:

Positive gyro bias is a positive rotation around the axis.

Positive accelerometer bias is a positive acceleration in the direction of the axis (i.e., a negative specific force along the axis).

Velocities shall be corrected according to states f and g. The above correction shall be performed and the control vector acknowledge bit (CVAB) in the INU Mode/Control word shall be set high within 35 milliseconds following reception of the F02 control vector. The CVAB shall be reset 40 to 80 milliseconds after being set. The transition of CVAB from high-to-low indicates the previous F02 correction has been fully applied to all outputs.

Vertical Loop Corrections:

The Vertical Corrections (Z) F02-27, Baro Bias correction F02-20 and Altitude Correction F02-29, shall be applied to the INU vertical loop in accordance with the following: (see Figure VI-3.)

a. Baro Bias Corrections are accumulated and the running accumulative total is constantly applied to the pressure altitude data being received from the air data computer.

b. Velocity Corrections (Z) and Altitude Corrections are applied within the reference vertical loop (not an exact representation of the INU vertical loop) as shown in Figure VI-3. When a velocity (Z) or altitude correction is received by the INU, the values will be retained. That is, a new altitude would be set equal to the present altitude plus the altitude correction. The same procedure holds for the velocity correction (Z).

c. Vertical loop operation/response during the first five minutes after pressure altitude has been set invalid shall be in accordance with Paragraph 3.2.1.9r. The pressure altitude is set equal to the internally derived inertial altitude. Thus the vertical channel of the INU will track the accelerometers during this period (see Figure VI-4). Only the Velocity (Z) and altitude corrections should be applied to the INU during this timeframe.

d. Vertical loop operation/response after five minutes of receiving pressure altitude invalid shall be IAW Paragraph 3.2.1.9r. Pressure altitude becomes fixed within the INU to the baro-inertial altitude value existing at the five minute time period. Thus the vertical channel of the INU will continue to track the accelerometers (see Figure VI-5). Altitude, Baro-bias, and Velocity (Z) corrections may be applied to the INU; however, before the first baro-bias correction is applied, any previously accumulated Baro-bias corrections that may be present must be set to zero. Then all received Baro-bias corrections are accumulated and the running total is applied to the frozen pressure altitude input.

The removal of tilt errors according to states h and i and the application of gyro biases according to states j through l shall begin at the first calculation of torquing rates following the reception of the control vector. Tilts shall be corrected at the highest rate consistent with normal torquing rates and maximum accurate torquing rates. Externally generated gyro biases shall be set equal to zero at INU power on. Tilt corrections are cumulative in that new tilt corrections are added to the previous corrections which have not yet been applied to the platform. Gyro biases are also cumulative.

States b through d contain corrections for the 3 navigation reference frame direction cosines which, with longitude corrections, define position update corrections to be applied to INU position. An alternative position update mechanism is available. See Note 1 on word F02-30. Direction cosines are defined in Paragraph 6.5.8.

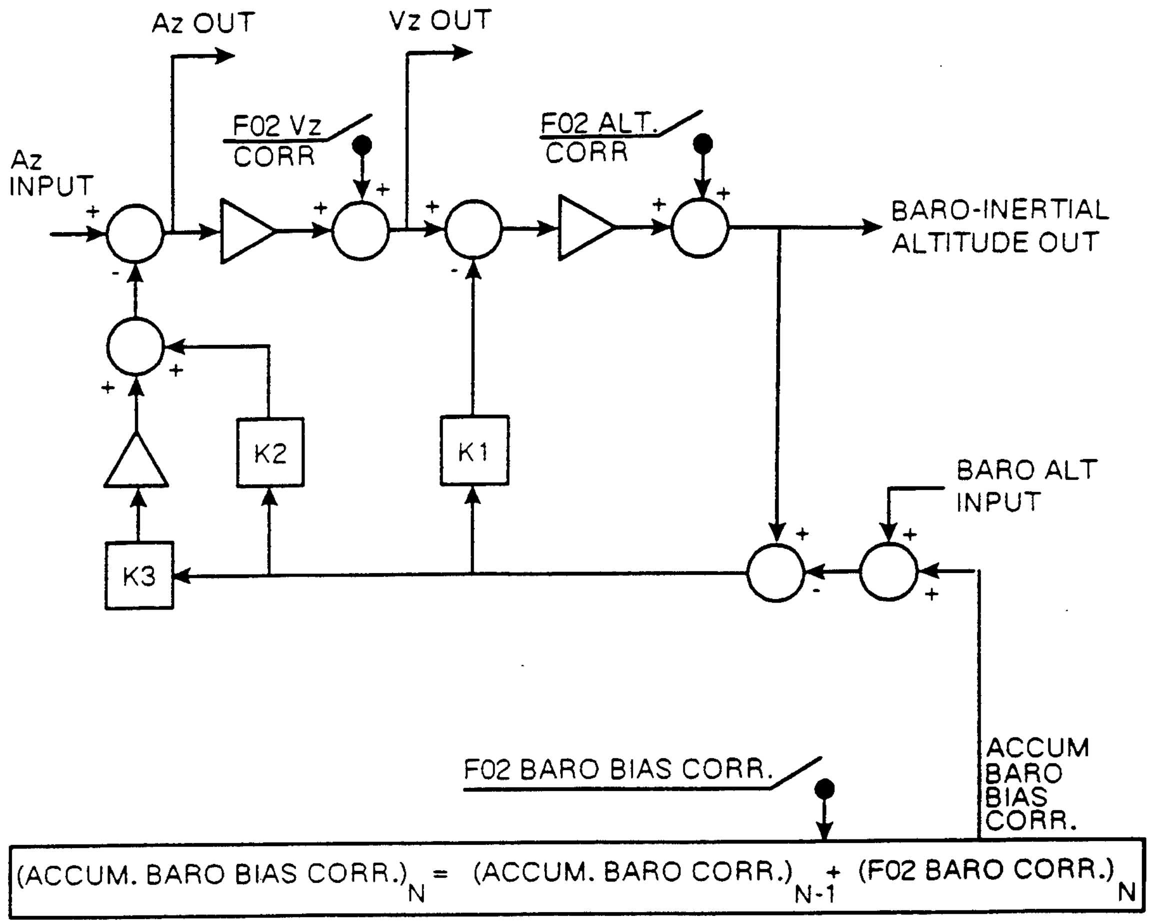


Figure VI-3
Implementation for Applying F02 Corrections to the Baro-Inertial Loop

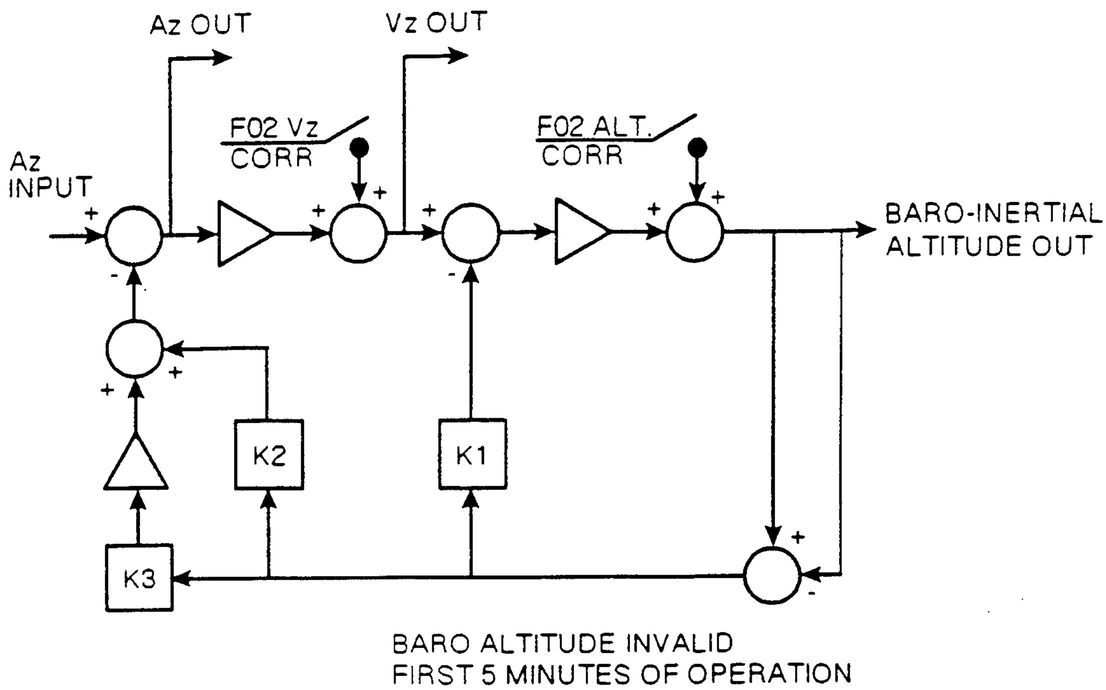


Figure VI-4
Implementation for Applying F02 Corrections to the Baro-Inertial Loop with Baro-Altitude Invalid for Up to 5 Minutes

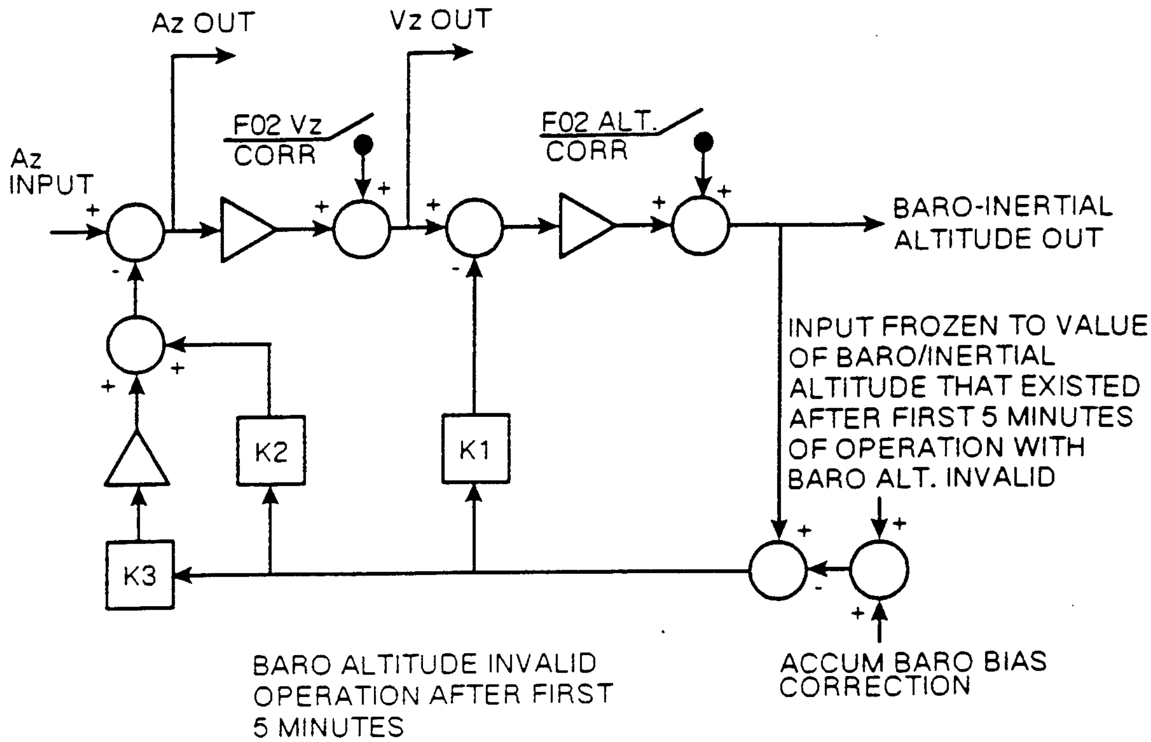


Figure VI-5
Implementation for Applying F02 Corrections to the Baro-Inertial Loop with Baro-Altitude Invalid for Longer than 5 Minutes

SUBADDRESS: 10001(T/R) WORD: F02-01

Signal Name - CC/INU Mode Word

DATA BIT	DESCRIPTION
1	Spare
2	Filter Mode
3	All Navigation Data Good (Note 1)
4	Reserved
5-16	Spares

Note 1: In the AIR ALIGN mode.

a. The Attitude and Mag Hdg Good discretes will echo this bit.

b. The degraded NAV flag (I06-01/I01-01 bit 3) will echo the complement of this bit.

c. When this bit is set, ATT Ready (I06-01/I01-01 bit 7) will be reset.

SUBADDRESS: 10001(T/R) WORD: F02-02 (MSP); F02-03 (LSP)

Signal Name - CNEXX Correction

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10001(T/R) WORD: F02-04 (MSP); F02-05 (LSP)

Signal Name - CNEXY Correction

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10001(T/R) WORD: F02-06 (MSP); F02-07 (LSP)
Signal Name - CNEXZ Correction

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10001(T/R) WORD: F02-08 (MSP); F02-09 (LSP)
Signal Name - Longitude Correction (pi rad)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (0.5)	18-31	*
3-16	*	32	LSB (4.65661E-10)

SUBADDRESS: 10001(T/R) WORD: F02-10
Signal Name - X Velocity Correction (fps)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4,096.0)
3-15	* (See Note 2, F02-30)
16	LSB (0.25)

SUBADDRESS: 10001(T/R) WORD: F02-11
Signal Name - Y Velocity Correction (fps)

DATA BIT	DESCRIPTION	
1	Sign Bit	
2	MSB (4,096.0)	(See Note 2, F02-30)
3-15	*	
16	LSB (0.25)	

SUBADDRESS: 10001(T/R) WORD: F02-12

Signal Name - X Tilt Correction (arc sec)

DATA BIT	DESCRIPTION	
1	Sign Bit	
2	MSB (16,384.0)	(See Note 2, F02-30)
3-15	*	
16	LSB (1.0)	

SUBADDRESS: 10001(T/R) WORD: F02-13

Signal Name - Y Tilt Correction (arc sec)

DATA BIT	DESCRIPTION	
1	Sign Bit	
2	MSB (16,384.0)	(See Note 2, F02-30)
3-15	*	
16	LSB (1.0)	

SUBADDRESS: 10001(T/R) WORD: F02-14

Signal Name - X Gyro Bias Correction (rad/s)

DATA BIT	DESCRIPTION	
1	Sign Bit	
2	MSB (6.10351E-05)	(See Note 2, F02-30)
3-15	*	
16	LSB (3.72529E-09)	

SUBADDRESS: 10001(T/R) WORD: F02-15

Signal Name - Y Gyro Bias Correction (rad/s)

DATA BIT	DESCRIPTION	
1	Sign Bit	
2	MSB (6.10351E-05)	(See Note 2, F02-30)
3-15	*	
16	LSB (3.72529E-09)	

SUBADDRESS: 10001(T/R) WORD: F02-16

Signal Name - Z Gyro Bias Correction (rad/s)

DATA BIT	DESCRIPTION	
1	Sign Bit	
2	MSB (6.10351E-05)	(See Note 2, F02-30)
3-15	*	
16	LSB (3.72524E-09)	

SUBADDRESS: 10001 (T/R) WORD: F02-17 (MSP) F02-18 (LSP)

Signal Name - CNEYX Correction

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10001 (T/R) WORD F02-19 (MSP) F02-20 (LSP)

Signal Name - CNEYY Correction

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10001 (T/R) WORD: F02-21 (MSP) F02-22 (LSP)

Signal Name - CNEYZ Correction

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10001 (T/R) . WORD: F02-23

Signal Name - Z Tilt Correction (arc sec)

DATA BIT	DESCRIPTION	
1	.ign Bit	
2	MSB (16,384.0)	(See Note 2, F02-30)
3-15	*	
16	LSB (1.0)	

SUBADDRESS: 10001 (T/R) WORD: F02-24
Signal Name - X Accelerometer Bias Correction (mg)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (8.192)
3-15	*
16	LSB (5.0E-04)

SUBADDRESS: 10001 (T/R) WORD: F02-25
Signal Name - Y Accelerometer Bias Corrections (mg)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (8.192)
3-15	*
16	LSB (5.0E-04)

SUBADDRESSES: 10001 (T/R) WORD: F02-26
Signal Name - Z Accelerometer Bias Correction (mg)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (8.192)
3-15	*
16	LSB (5.0E-04)

SUBADDRESSES: 10001 (T/R) WORD F02-27
Signal Name - Z Velocity Correction (fps)

DATA BIT	DESCRIPTION	
1	Sign Bit	
2	MSB (4096)	(see Note 2, F02-30)
3-15	*	
16	LSB (0.25)	

SUBADDRESSES: 10001 (T/R) WORD: F02-28

Signal Name - Baro-Bias Correction (ft)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2048.0)
3-15	*
16	LSB (0.125)

SUBADDRESSES: 10001 (T/R) WORD: F02-29

Signal Name - Altitude Correction (ft)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2048.0)
3-15	*
16	LSB (0.125)

SUBADDRESSES: 10001 (T/R) WORD: F02-30

Signal Name - 2nd MODE Word

DATA BIT	DESCRIPTION
1 (See Note 1)	0 for old update method (1 row DCM and Longitude) 1 for new update method (2nd row DCM correction)
2 (See Note 2)	0 the current scaling 1 the scaling for velocity, tilt and gyro bias corrections are divided by 16 for enhanced, precision and high accuracy applications.
3 (See Note 3)	Command Slew Rate X, 0-No Slew, 1-Slew
4 (See Note 3)	Direction X, 0-positive, 1-negative direction
5 (See Note 3)	Command Slew Rate Y, 0-No Slew, 1-Slew
6 (See Note 3)	Direction Y, 0-positive, 1-negative direction
7 (See Note 3)	Command Slew Rate Z, 0-No Slew, 1-Slew
8 (See Note 3)	Direction Z, 0-positive, 1-negative direction
9	Always 1 to indicate longer F02 message
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

Note 1: Two methods of correcting position and wander angle are available. The method to be used by the INU is determined by the value of this bit.

When Bit-0: This method was used in previous editions of the specification. It is subject to numerical degradation in polar regions (abs(lat>75 deg)) and is indeterminate at the pole. It consists of corrections to the first row of CNE(F02-02 through F02-07) and longitude (F02-08,09).

When Bit-1: This method will work in all regions. It consists of corrections to the first row of CNE (F02-02 through F02-07) and the second row of CNE (F02-17 through F02-22).

Note 2: Two sets of scale factors are available for the following quantities:

velocity corrections
tilt corrections
gyro bias corrections

When bit-0: The normal scale factors apply.

When bit-1: The scale factors are 1/16 the normal value, i.e. if the MSB was equal to 1, it would be rescaled to 1/16.

Note 3: Data bits 3 through 8 are for use in air aligning gimbaled systems. See I13-01 through I13-06 for further details.

BLOCK ID: I01/I05 Refresh Rate = 50Hz Transmit Rate = 50Hz

SUBADDRESS: 10000(T) WORD: I01/I05-01

Signal Name - INU Mode Word

DATA BIT	DESCRIPTION	
1	Inertial Sensor/Reference Fail	(Note 1)
2	Any Navigation Data Fail	**(See Remarks)**
3	Degraded Navigation	(Note 2)
4	Navigation Data Unavailable	(Note 3)
5	Digital Attitude Data Fail	
6	Degraded NAV Ready	(Note 4)
7	Attitude Ready	(Note 5)
8	Control Vector Acknowledge	(Note 6)
9	Altitude Loop Bit	(Note 7)
10	INU in Initiated Bit	(Note 8)
11	Mechanization Flag	(Note 9)
12	In Manual Magnetic Variation	(Note 10)
13	Digital Select	(Note 11)
14	In Grid Mode	(Note 12)
15	CDU Fail	(Note 13)
16	Logic "0"	

REMARKS: A logical "1" shall indicate that the referenced condition is true. Navigation data is defined to be INU computed data exclusive of attitude data, where attitude data is defined to be platform azimuth (not true/magnetic heading), roll, and pitch. **Bit 2 is applicable to failures (not invalid data) of digital NAV data only, not attitude data. Reference Time-lines figures 3.2.1.10-1 thru 3.2.1.10-6.**

Note 1: Inertial source data has failed and no navigation or attitude data is available.

Note 2: The INU is in the NAV mode and degraded performance is expected as a result of the performance of a Degraded Performance Alignment, in accordance with Table I, or a detected failure.

Note 3: The INU is not in the NAV, OVERFLY, AIR ALIGN or AUXILIARY mode.

Note 4: The NAV mode may be entered with at least degraded navigation performance in accordance with Table I.

Note 5: Usable attitude data of $\leq$ 1 degree of uncertainty is available.

Note 6: Acknowledge receipt of all F02 correction vectors in all system modes. In addition, when used in the generalized CDU Air Align mode, this bit provides an acknowledgement that a block of F02 data has been received and applied per the description on FORMAT Section V, Filter/Sensor to INU correction vector.

Note 7: Baro-Inertial data is invalid. A CADC failure in the Align mode will cause this bit to be set immediately. A CADC failure in the NAV mode will cause this bit to be set after five seconds of a continuous CADC failure.

Note 8: The INU is in the Initiated Built-In-Test (BIT) mode. This bit shall be reset to logic "0" upon completion of the Initiated BIT mode.

Note 9: This bit is used by non-standard INUs to indicate the sense of Z axis torquing. Standard INU designs conforming to this specification shall not mechanize Z axis torquing and shall set this bit to logic "0" for gimbaled systems and logic "1" for strapdown systems.

Note 10: Manually entered magnetic variation is used in the computation of all magnetic related outputs.

Note 11: Digital Select Flag Acknowledge. This bit shall be set to a logic "1" in response to receiving a logic "1" in a corresponding bit of D01-02. Subsequent to the INU receiving a logic "0" in the corresponding bit of D01-02, the INU shall reset this bit to a logic "0". Digitally entered Selected Magnetic Course is used in lieu of analog (HSI) selected course.

Note 12: Grid Mode Flag Acknowledge. This bit shall be set to a logic "1" in response to receiving a logic "1" in a corresponding bit of D01-02. Subsequent to the INU receiving a logic "0" in the corresponding bit of D01-02, the INU shall reset this bit to logic "0". INU magnetic heading outputs (digital and analog) shall be replaced by grid heading in this mode.

Note 13: Echo of D01-01 bit 1 CDU fault flag

SUBADDRESS: 10000(T) WORD: I01/I05-02 through I01/I05-13

Signal Name - [Note: These words are identical to I06/I08-02 through I06/I08 -13. Subsystem receiver subaddress I05 is shown in Table VI-2.]

SUBADDRESS: 10000(T) WORD: I01-14
Signal Name - X Acceleration (ft/s^2)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (512.0)
3-15	*
16	LSB (0.03125)

SUBADDRESS: 10000(T) WORD: I01-15
Signal Name - Y Acceleration (ft/s^2)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (512.0)
3-15	*
16	LSB (0.03125)

SUBADDRESS: 10000(T) WORD: I01-16
Signal Name - Z Acceleration (ft/s^2)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (512.0)
3-15	*
16	LSB (0.03125)

REMARKS: Acceleration consists of accelerometer reading plus coriolis compensation. The static condition output reading shall be approximately +1 g.

NOTE: Words I01-17 through I01-24 contain "pure inertial" information.

SUBADDRESS: 10000(T) WORD: I01-17(MSP); I01-18(LSP)
Signal Name - CNEXX

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10000(T) WORD: I01-19(MSP); I01-20(LSP)
Signal Name - CNEXY

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10000(T) WORD: I01-21(MSP); I01-22(LSP)
Signal Name - CNEXZ

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10000(T) WORD: I01-23(MSP); I01-24(LSP)
Signal Name - Longitude (pi rad)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (0.5)	18-31	*
3-16	*	32	LSB (4.65661E-10)

SUBADDRESS: 10000(T) WORD: I01-25

Signal Name - Inertial Altitude (ft)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (65,536.0)
3-15	*
16	LSB (4.0)

REMARKS: Positive direction is up.

SUBADDRESS: 10000(T) WORD: I01-26

Signal Name - Great Circle Steering Error (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05175E-05)

SUBADDRESS: 10000(T) WORD: I01-27

Signal Name - X-Axis Residual Tilt (arc sec)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16,384.0)
3-15	*
16	LSB (1.0)

SUBADDRESS: 10000(T) WORD: I01-28

Signal Name - Y-Axis Residual Tilt (arc sec)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16,384.0)
3-15	*
16	LSB (1.0)

SUBADDRESS: 10000(T) WORD: I01-29
Signal Name - Mode Word II

DATA BIT	DESCRIPTION
1	Off
2	Standby
3	Air Align
4	Stored Heading Align
5	GC Align
6	Enhanced GC Align (Reserved)
7	Precision GC Align (Reserved)
8	EIA (Reserved)
9	Navigate
10	Overfly
11	Auxiliary
12	Orient/Boresight
13	Attitude
14	Test
15	Calibrate (Reserved)
16	Spare

Note: This is the current operational mode of the INU.

SUBADDRESS: 10000 (T) WORD: I01-30
SIGNAL NAME - Roll Rate (p) (pi rad/s)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2.0)
3-15	*
16	LSB (1.22070E-04)

SUBADDRESS: 10000 (T) WORD: I01-31
SIGNAL NAME - Pitch Rate (q) (pi rad/s)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2.0)
3-15	*
16	LSB (1.22070E-04)

SUBADDRESS: 10000 (T) WORD: I01-32
SIGNAL NAME - Yaw Rate (r) (pi rad/s)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2.0)
3-15	*
16	LSB (1.22070E-04)

Note: p, q, and r include earth rate.

BLOCK ID: C01/C02/C03 Refresh Rate = 20Hz Transmit Rate=25Hz

SUBADDRESS: 10000(T); 11110(R:C01); 11101(R:C02); 10011(R:C03)
WORD: C01/C02/C03-01

Signal Name - CADC MODE WORD

DATA BIT	DESCRIPTION
1	Pressure Altitude Valid
2	Baro Reference Altitude Valid
3	TAS/AIR Density Ratio Valid
4	Mach Number Valid
5	Calibrated Airspeed Valid
6	Pressure Ratio Valid
7	True Angle of Attack Valid
8	True Freestream Air Temp Valid
9-16	Spares

REMARKS: A logic "1" represents a valid signal; A Logic "0" represents an invalid signal.

SUBADDRESS: 10000(T); 11110(R:C01); 11101(R:C02); 10011(R:C03)
WORD: C01/C02/C03-02

Signal Name - Pressure Altitude (ft)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (40,960.0)
3-15	*
16	LSB (2.5)

SUBADDRESS: 10000(T); 11110(R:C01); 11101(R:C02); 10011(R:C03)
WORD: C01/C02/C03-03

Signal Name - Baro Reference Altitude (ft)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (40,960.0)
3-15	*
16	LSB (2.5)

SUBADDRESS: 10000(T); 11110(R:C01); 11101(R:C02); 10011(R:C03)
WORD: C01/C02/C03-04

Signal Name - True Airspeed (knots)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1,024.0)
3-14	*
15	LSB (0.125)
16	Spare

SUBADDRESS: 10000(T); 11110(R:C01); 11101(R:C02)
WORD: C01/C02-05

Signal Name - Mach Number (M)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2.0)
3-14	*
15	LSB (2.44141E-04)
16	Spare

SUBADDRESS: 10000(T); 11110(R:C01); 11101(R:C02)
WORD: C01/C02-06

Signal Name - Calibrated Airspeed (knots)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (512.0)
3-14	*
15	LSB (0.0625)
16	Spare

SUBADDRESS: 10000(T); 11110(R:C01); 11101(R:C02)
WORD: C01/C02-07

Signal Name - True Angle of Attack (deg)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (90.0)
3-15	*
16	LSB (5.49316E-03)

REMARKS: Signal is relative to the aircraft velocity vector. **Angle of attack is positive when Flight Reference Line (FRL) is above** velocity vector.

SUBADDRESS: 10000(T); 11110(R:C01); 11101(R:C02)

WORD: C01/C02-08

Signal Name - Pressure Ratio (p/p_o)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1.0)
3-14	*
15	LSB (1.22070E-04)
16	Spare

SUBADDRESS: 10000(T); 11110(R:C01); 11101(R:C02)

WORD: C01/C02-09

Signal Name - Air Density Ratio (rho/rho_o)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1.0)
3-14	*
15	LSB (1.22070E-04)
16	Spare

SUBADDRESS: 10000(T); 11110(R) WORD: C01-10

Signal Name - True Freestream Air Temperature (degrees Kelvin)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (256.0)
3-14	*
15	LSB (0.03125)
16	Spare

BLOCK ID: F12/F16 Refresh Rate = As Req Transmit Rate = 1.5625Hz

SUBADDRESS: 10110(R:F12); 10101(R:F16) WORD: F12/F16-01
Signal Name - Mode Word

DATA BIT	DESCRIPTION
1	Spare
2	Logic "0"
3-16	Spares

SUBADDRESS: 10110(R:F12); 10101(R:F16) WORD: See Note 1

Signal Name - Waypoint/Markpoint Coordinates (Latitude & Longitude) (pi rad)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (0.5)	18-31	*
3-16	*	32	LSB (4.65661E-10)

REMARKS: Accuracy shall be 0.1 Arc Minutes. Positive sense is North for latitude and East for longitude.

Note 1: The latitude and longitude coordinates are double precision inputs with word assignments for the MSP and LSP as follows:

MESSAGE BLOCK/WORD ASSIGNMENT		
WAYPOINT NO.	LATITUDE (MSP/LSP)	LONGITUDE (MSP/LSP)
WP 0	F16/02/F16-03	F16-04/F16-05
WP 1	F16/06/F16-07	F16-08/F16-09
WP 2	F16-10/F16-11	F16-12/F16-13
WP 3	F16-14/F16-15	F16-16/F16-17
WP 4	F16-18/F16-19	F16-20/F16-21
WP 5	F16-22/F16-23	F16-24/F16-25
WP 6	F16-26/F16-27	F16-28/F16-29
WP 7	F12-02/F12-03	F12/04/F12-05
WP 8	F12-06/F12-07	F12-08/F12-09
WP 9	F12-10/F12-11	F12-12/F12-13
MARKPOINT NO.	LATITUDE (MSP/LSP)	LONGITUDE (MSP/LSP)
MP 1	F12-14/F12-15	F12-16/F12-17
MP 2	F12-18/F12-19	F12-20/F12-21
MP 3	F12-22/F12-23	F12-24/F12-25

BLOCK ID: F17 Refresh Rate - As Req Transmit Rate - As Req

SUBADDRESS: 10010(R) WORD: F17-01

Signal Name - Mode Word

DATA BIT	DESCRIPTION
1	Spare
2	Logic "0"
3-16	Spares

SUBADDRESS: 10010(R) WORD: F17-02

Signal Name - Steering Error (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

Block ID: IH1 Refresh/Transmit Rates: 200 HZ
SUBADDRESS: 11010 (T) WORD: IH1-01
SIGNAL NAME - Pitch (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

REMARKS: Positive sense is nose up.

SUBADDRESS: 11010 (T) WORD: IH1-02
SIGNAL NAME - Roll (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

Remarks: Positive sense is right bank (right wing down).

SUBADDRESS: 11010 (T) WORD: IH1-03
SIGNAL NAME - True Heading (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

REMARKS: Positive sense is CW WRT true North.

SUBADDRESS: 11010 (T) WORD: IH1-04
SIGNAL NAME - North - South Velocity (fps)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2,048.0)
3-15	*
16	LSB (0.125)

REMARKS: Positive direction is North.

SUBADDRESS: 11010 (T) WORD: IH1-05

SIGNAL NAME - East - West Velocity (fps)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2,048.0)
3-15	*
16	LSB (0.125)

Remarks: Positive direction is East

SUBADDRESS: 11010 (T) WORD: IH1-06

SIGNAL NAME - Vertical Velocity (fps)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1,024.0)
3-15	*
16	LSB (0.0625)

REMARKS: Positive direction up.

SUBADDRESS: 11010 (T) WORD: IH1-07

SIGNAL NAME - Platform Azimuth (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

SUBADDRESS: 11010 (T) WORD: IH1-08 (MSP)
IH1-09 (LSP)

SIGNAL NAME - X Velocity (fps)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (4,096.0)	18-31	*
3-16	*	32	LSB (3.81470E-10)

SUBADDRESS: 11010 (T) WORD: IH1-10 (MSP)
IH1-11 (LSP)

SIGNAL NAME - Y Velocity (fps)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (4,096.0)	18-31	*
3-16	*	32	LSB (3.81470E-06)

SUBADDRESS: 11010 (T) WORD: IH1-12 (MSP)
IH1-13 (LSP)

SIGNAL NAME - Z Velocity (fps)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (4,096.0)	18-31	*
3-16	*	32	LSB (3.81470E-06)

SUBADDRESS: 11010 (T) WORD: IH1-14
SIGNAL NAME - Velocity Time Tag (micro sec)

DATA BIT	DESCRIPTION
1	MSB (2,097,152.0)
2-15	*
16	LSB (64.0)

SUBADDRESS: 11010 (T) WORD: IH1-15
SIGNAL NAME - Platform Azimuth Time Tag (micro sec)

DATA BIT	DESCRIPTION
1	MSB (2,097,152.0)
2-15	*
16	LSB (64.0)

SUBADDRESS: 11010 (T) WORD: IH1-16
SIGNAL NAME - Roll Time Tag (micro sec)

DATA BIT	DESCRIPTION
1	MSB (2,097,152.0)
2-15	*
16	LSB (64.0)

SUBADDRESS: 11010 (T) WORD: IH1-17
SIGNAL NAME - Pitch Time Tag (micro sec)

DATA BIT	DESCRIPTION
1	MSB (2,097,152.0)
2-15	*
16	LSB (64.0)

Block ID: I09 Refresh/Rate: 200Hz Transmit Rate = 200Hz

SUBADDRESS: 10011 WORD I09-01

SIGNAL NAME - INU Mode Word

DATA BIT DESCRIPTION

The INU Mode Words for I09 and I01/I05 are identical.

SUBADDRESS: 10011 WORD: I09-02 through I09-11

SIGNAL NAME - [NOTE: These wo s are identical to I06/I08-02 thr gh I06/I08-11].

SUBADDRESS: 10011 WORD: I09-12
SIGNAL NAME - Roll Rate (p) (pi rad/s)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2.0)
3-15	*
16	LSB (1.22070E-04)

SUBADDRESS: 10011 WORD: I09-13
SIGNAL NAME - Pitch Rate (q) (pi rad/s)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2.0)
3-15	*
16	LSB (1.22070E-04)

SUBADDRESS: 10011 WORD: I09-14
SIGNAL NAME - Yaw Rate (r) (pi rad/s)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2.0)
3-15	*
16	LSB (1.22070E-04)

SUBADDRESS: 10011 WORD: I09-15

SIGNAL NAME - Longitudinal Acceleration (n_x) (ft/s^2)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (512.0)
3-15	*
16	LSB (0.03125)

Remarks: Body acceleration is computed at the center of specific force (see section 6.4).

SUBADDRESS: 10011 WORD: I09-16

SIGNAL NAME - Lateral Acceleration (n_y) (ft/s^2)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (512.0)
3-15	*
16	LSB (0.03125)

Remarks: See Word I09-15 remarks.

SUBADDRESS: 10011 WORD: I09-17

SIGNAL NAME - Normal Acceleration (n_z) (ft/s^2)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (512.0)
3-15	*
16	LSB (0.03125)

Remarks: See Word I09-15 remarks.

WORD: I09-18

SIGNAL NAME - Platform Azimuth Time Tag (micro sec)

DATA BIT	DESCRIPTION
1	MSB (2,097,152.0)
2-15	*
16	LSB (64.0)

WORD: I09-19

SIGNAL NAME - Roll Time Tag (micro sec)

DATA BIT	DESCRIPTION
1	MSB (2,097,152.0)
2-15	*
16	LSB (64.0)

WORD: I09-20

SIGNAL NAME - Pitch Time Tag (micro sec)

DATA BIT	DESCRIPTION
1	MSB (2,097,152.0)
2-15	*
16	LSB (64.0)

SUBADDRESS: 10011 WORD: I09-21

SIGNAL NAME - Roll Axis Angular Acceleration (pi rad/s^2)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4.0)
3-15	*
16	LSB (2.44141E-04)

SUBADDRESS: 10011 WORD: I09-22

SIGNAL NAME - Pitch Axis Angular Acceleration (pi rad/s^2)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4.0)
3-15	*
16	LSB (2.44141E-04)

SUBADDRESS: 10011 WORD: I09-23

SIGNAL NAME - Yaw Axis Angular Acceleration (pi rad/s^2)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4.0)
3-15	*
16	LSB (2.44141E-04)

Block ID: I10 Refresh Rate - 12.5Hz Transmission Rate - 12.5Hz

Note: Parameters contained in I10 words are one sigma values.

SUBADDRESS: 10010 WORD: I10-01
SIGNAL NAME - Time Tag (micro sec)

DATA BIT	DESCRIPTION
1	MSB (2,097,152.0)
2-15	*
16	LSB (64.0)

REMARKS: This word shall be updated continuously after power-up/system initialization (approximately 5 seconds). **This time tag is referenced to the beginning of the velocity computation cycle.**

SUBADDRESS: 10010 WORD: I10-02
SIGNAL NAME - X Axis Residual Tilt (arc sec)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16,384.0)
3-15	*
16	LSB (1.0)

SUBADDRESS: 10010 WORD: I10-03
SIGNAL NAME - Y Axis Residual Tilt (arc sec)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16,384.0)
3-15	*
16	LSB (1.0)

SUBADDRESS: 10010 WORD: I10-04
SIGNAL NAME - Z Axis Residual Tilt (arc sec)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16,384.0)
3-15	*
16	LSB (1.0)

SUBADDRESS: 10010 WORD: I10-05 (MSP)
I10-06 (LSP)

SIGNAL NAME - CNExx

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10010 WORD: I10-07 (MSP)
I10-08 (LSP)

SIGNAL NAME - CNExy

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31.23E-10)

SUBADDRESS: 10010 WORD: I10-09 (MSP)
I10-10 (LSP)

SIGNAL NAME - CNExz

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10010 WORD: I10-11 (MSP)
I10-12 (LSP)

SIGNAL NAME - CNEyx

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10010 WORD: I10-13 (MSP)
I10-14 (LSP)

SIGNAL NAME - CNEyy

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10010 WORD: I10-15 (MSP)
I10-16 (LSP)

SIGNAL NAME - CNEyz

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

SUBADDRESS: 10010 WORD: I10-17
SIGNAL NAME - CSNxx

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1.0)
3-15	*
16	LSB (6.10352E-05)

REMARKS: See Sections 6.5.2 and 6.5.4 for details.

SUBADDRESS: 10010 WORD: I10-18
SIGNAL NAME - CSNxy

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1.0)
3-15	*
16	LSB (6.10352E-05)

REMARKS: See Sections 6.5.2 and 6.5.4 for details.

SUBADDRESS: 10010 WORD: I10-19
SIGNAL NAME - CSNxz

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1.0)
3-15	*
16	LSB (6.10352E-05)

REMARKS: See Sections 6.5.2 and 6.5.4 for details.

SUBADDRESS: 10010 WORD: I10-20
SIGNAL NAME - CSNyx

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1.0)
3-15	*
16	LSB (6.10352E-05)

REMARKS: See Sections 6.5.2 and 6.5.4 for details.

SUBADDRESS: 10010 WORD: I10-21
SIGNAL NAME - CSNyy

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1.0)
3-15	*
16	LSB (6.10352E-05)

REMARKS: See Sections 6.5.2 and 6.5.4 for details.

SUBADDRESS: 10010 WORD: I10-22
SIGNAL NAME - CSNyz

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1.0)
3-15	*
16	LSB (6.10352E-05)

REMARKS: See Sections 6.5.2 and 6.5.4 for details.

SUBADDRESS: 10010 WORD: I10-23 (MSP)
I10-24 (LSP)

SIGNAL NAME - Altitude Feedback Constant (1/sec)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (3.0) (See Note)	18-31	*
3-16	*	32	LSB (2.79397E-09)

Note: These constants are the best fit to a steady state third order vertical loop.

SUBADDRESS: 10010 WORD: I10-25 (MSP)
I10-26 (LSP)

SIGNAL NAME - Velocity Feedback Constant (1/sec^2)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (3.0) (See Note)	18-31	*
3-16	*	32	LSB (2.79397E-10)

Note: These constants are the best fit to a steady third order vertical loop.

SUBADDRESS: 10010 WORD: I10-27 (MSP)
I10-28 (LSP)

SIGNAL NAME - Acceleration Feedback Constant (1/sec^3)

DATA BIT	DESCRIPTION (MSP)	DATA BIT	DESCRIPTION (LSP)
1	Sign Bit	17	*
2	MSB (1.0)	18-31	*
3-16	*	32	LSB (9.31323E-10)

Note: These constants are the best fit to a steady state third order vertical loop.

Block ID: I11 Refresh Rate = As required Transmission Rate = As Required

Note: Parameters contained in I11 words are one sigma values and represent INU error budget uncertainty constants unless otherwise indicated.

SUBADDRESS: 10110 WORD: I11-01
SIGNAL NAME - RESERVED

SUBADDRESS: 10110 WORD: I11-02
SIGNAL NAME - (X,Y,Z) Accelerometer Bias Uncertainty (mg)

DATA BIT	DESCRIPTION
1	MSB (52.4288)
2-15	*
16	LSB (0.0016)

SUBADDRESS: 10110 WORD: (SF) I11-03
SIGNAL NAME - (X,Y,Z) Accelerometer Scale Factor Uncertainty (%)

DATA BIT	DESCRIPTION
1	MSB (0.32768)
2-15	*
16	LSB (1.0E-05)

SUBADDRESS: 10110 WORD: I11-04
SIGNAL NAME - X Gyro Bias Uncertainty (deg/hr)

DATA BIT	DESCRIPTION
1	MSB (0.32768)
2-15	*
16	LSB (1.0E-05)

SUBADDRESS: 10110 WORD: I11-05
SIGNAL NAME - Y Gyro Bias Uncertainty (deg/hr)

DATA BIT	DESCRIPTION
1	MSB (0.32768)
2-15	*
16	LSB (1.0E-05)

SUBADDRESS: 10110 WORD: I11-06
SIGNAL NAME - Z Gyro Bias Uncertainty (deg/hr)

DATA BIT	DESCRIPTION
1	MSB (0.32768)
2-15	*
16	LSB (1.0E-05)

SUBADDRESS: 10110 WORD: I11-07
SIGNAL NAME - X,Y,Z Gyro SF Uncertainty (%)

DATA BIT	DESCRIPTION
1	MSB (0.32768)
2-15	*
16	LSB (1.0E-05)

SUBADDRESS: 10110 WORD: I11-08
SIGNAL NAME - X Gyro Randomness (deg/hr)

DATA BIT	DESCRIPTION
1	MSB (0.032768) (See Note)
2-15	*
16	LSB (1.0E-06)

Note: If I11-09 correlation time is 0 minutes, the MSB is Deg/square root hour and I11-08 represents random walk.

SUBADDRESS: 10110 WORD: I11-09
SIGNAL NAME - X Gyro Correlation Time (min)

DATA BIT	DESCRIPTION
1	MSB (327.68)
2-15	*
16	LSB (0.01)

SUBADDRESS: 10110 WORD: I11-10
SIGNAL NAME - Y Gyro Randomness (deg/hr)

DATA BIT	DESCRIPTION
1	MSB (0.032768)(See Note)
2-15	*
16	LSB (1.0E-06)

Note: If I11-11 correlation time is 0 minutes, the MSB is Deg/square root hour and I11-10 represents random walk.

SUBADDRESS: 10110 WORD: I11-11

SIGNAL NAME - Y Gyro Correlation Time (min)

DATA BIT	DESCRIPTION
1	MSB (327.68)
2-15	*
16	LSB (0.01)

SUBADDRESS: 10110 WORD: I11-12

SIGNAL NAME - Z Gyro Randomness (deg/hr)

DATA BIT	DESCRIPTION
1	MSB (0.032768)(See Note)
2-15	*
16	LSB (1.0E-06)

Remarks: This word can be considered as a white acceleration noise or random walk velocity.

Note: If I11-13 correlation time is zero minutes, the MSB is Deg/square root hour and I11-12 represents random walk.

SUBADDRESS: 10110 WORD: I11-13

SIGNAL NAME - Z Gyro Correlation Time (min)

DATA BIT	DESCRIPTION
1	MSB (327.68)
2-15	*
16	LSB (0.01)

SUBADDRESS: 10110 WORD: I11-14

SIGNAL NAME - X,Y,Z Accelerometer Randomness (mg)

DATA BIT	DESCRIPTION
1	MSB (0.32768)
2-15	*
16	LSB (1.0E-05)

SUBADDRESS: 10110 WORD: I11-15
SIGNAL NAME - X,Y,Z Accelerometer Randomness Correlation Time (min)

DATA BIT	DESCRIPTION
1	MSB (327.68)
2-15	*
16	LSB (0.01)

SUBADDRESS: 10110 WORD: I11-16
SIGNAL NAME - X Gyro Input/Quad Mass Unbalance (MUB) Uncertainty

(RESERVED, SET TO ZERO)

SUBADDRESS: 10110 WORD: I11-17
SIGNAL NAME - Y Gyro Input/Quad Mass Unbalance (MUB) Uncertainty

(RESERVED, SET TO ZERO)

SUBADDRESS: 10110 WORD: I11-18
SIGNAL NAME - Z Gyro Input/Quad Mass Unbalance (MUB) Uncertainty

(RESERVED, SET TO ZERO)

SUBADDRESS: 10110 WORD: I11-19
SIGNAL NAME - X,Y Platform Tilt (Ground Align) Uncertainty (arc sec)

DATA BIT	DESCRIPTION
1	MSB (32,768.0)
2-15	*
16	LSB (1.0)

Note: Updated at align-to-nav transition.

SUBADDRESS: 10110 WORD: I11-20
SIGNAL NAME - Z Platform Azimuth (Ground Align) Uncertainty (arc sec)

DATA BIT	DESCRIPTION
1	MSB (32,768.0)
2-15	*
16	LSB (1.0)

Note: Updated at align-to-nav transition.

SUBADDRESS: 10110 WORD: I11-21
SIGNAL NAME - X,Y,Z Accelerometer Nonorthogonality Uncertainty (arc sec)

DATA BIT	DESCRIPTION
1	MSB (32,768.0)
2-15	*
16	LSB (1.0)

SUBADDRESS: 10110 WORD: I11-22
SIGNAL NAME - (RESERVED, SET TO ZERO)

SUBADDRESS: 10110 WORD: I11-23
SIGNAL NAME - (RESERVED, SET TO ZERO)

SUBADDRESS: 10110 WORD: I11-24
SIGNAL NAME - X,Y,Z Gyro Misalignment Uncertainty (arc sec)

DATA BIT	DESCRIPTION
1	MSB (32,768.0)
2-15	*
16	LSB (1.0)

SUBADDRESS: 10110 WORD: I11-25
SIGNAL NAME - (RESERVED, SET TO ZERO)

SUBADDRESS: 10110 WORD: I11-26
SIGNAL NAME - (RESERVED, SET TO ZERO)

Block ID: I12 Refresh Rate = As Required Transmission Rate = As Required
SUBADDRESS: 10111 WORD: I12-01
SIGNAL NAME - (RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-02
SIGNAL NAME - Accelerometer Scale Factor Asymmetry (PPM)

DATA BIT	DESCRIPTION
1	MSB (3,276.8)
2-15	*
16	LSB (0.1)

SUBADDRESS: 10111 WORD: I12-03
SIGNAL NAME - Gravity Compensation
(RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-04
SIGNAL NAME - Gravity Compensation Correlation Distance
(RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-05
SIGNAL NAME - X Gyro Trending
(RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-06
SIGNAL NAME - Y Gyro Trending
(RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-07
SIGNAL NAME - Z Gyro Trending
(RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-08
SIGNAL NAME - X Gyro Warmup
(RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-09
SIGNAL NAME - X Gyro Warmup Correlation Time
(RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-10
SIGNAL NAME - Y Gyro Warmup
(RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-11
SIGNAL NAME - Y Gyro Warmup Correlation Time
(RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-12
SIGNAL NAME - Z Gyro Warmup
(RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-13
SIGNAL NAME - Z Gyro Warmup Correlation Time
(RESERVED, SET TO ZERO)

SUBADDRESS: 10111 WORD: I12-14
SIGNAL NAME - Accelerometer Warmup (mg)

DATA BIT	DESCRIPTION
1	MSB (32.768)
2-15	*
16	LSB (0.001)

SUBADDRESS: 10111 WORD: I12-15
SIGNAL NAME - Accelerometer Warmup Correlation Time (min)

DATA BIT	DESCRIPTION
1	MSB (327.68)
2-15	*
16	LSB (0.01)

Block ID: I13 Refresh Rate - As Required Transmission Rate - As Required

SUBADDRESS: 11000 WORD: I13-01
SIGNAL NAME - Max normal rate for X precision torquing
(RESERVED, SET TO ZERO)

SUBADDRESS: 11000 WORD: I13-02
SIGNAL NAME - Max normal rate for Y precision torquing
(RESERVED, SET TO ZERO)

SUBADDRESS: 11000 WORD: I13-03
SIGNAL NAME - Max normal rate for Z precision torquing
(RESERVED, SET TO ZERO)

SUBADDRESS: 11000 WORD: I13-04
SIGNAL NAME - Max slewing rate for X coarse slewing
(RESERVED, SET TO ZERO)

SUBADDRESS: 11000 WORD: I13-05
SIGNAL NAME - Max slewing rate for Y coarse slewing
(RESERVED, SET TO ZERO)

SUBADDRESS: 11000 WORD: I13-06
SIGNAL NAME - Max slewing rate for Z coarse slewing
(RESERVED, SET TO ZERO)

SUBADDRESS: 11000 WORD: I13-07
SIGNAL NAME - Position of the Specific Force Origin in Xr (in)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16.384)
3-15	*
16	LSB (0.001)

Remarks: Refer to definitions of specific force origin (Section 6.4) and the chassis frame (Section 6.4.7).

SUBADDRESS: 11000 WORD: I13-08

SIGNAL NAME - Position of the Specific Force Origin in Yr (in)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16.384)
3-15	*
16	LSB (0.001)

Remarks: Refer to definitions of specific force origin (Section 6.4) and the chassis frame (Section 6.4.7).

SUBADDRESS: 11000 WORD: I13-09

SIGNAL NAME - Position of the Specific Force Origin in Zr (in)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16.384)
3-15	*
16	LSB (0.001)

Remarks: The position of Specific Force Origin shall be defined as the distances along the Xr, Yr, Zr Axes.

SUBADDRESS: 11000 WORD: I13-10

SIGNAL NAME - Gyro Orientation About Z_b, gamma Z_o (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

Remarks: The orientation of the instrument axes shall be defined relative to the sensor coordinate frame X_s, Y_s, Z_s. For a strapdown system, the sensor coordinates are defined to be identical to the aircraft body frame X_b, Y_b, Z_b. Euler angles shall be used to define the requisite orientation of the X_o, Y_o, Z_o instrument frame. These angles shall be called gamma X_o, gamma Y_o, gamma Z_o. The order of rotation shall be gamma Z_o about Z_s, gamma Y_o about the new Y_s axis, and gamma X_o about the final X_s axis.

SUBADDRESS: 11000 WORD: I13-11

SIGNAL NAME - Gyro Orientation About Y_b, gamma Y_o (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

Remarks: See Remarks Word I13-10.

SUBADDRESS: 11000 WORD: I13-12

SIGNAL NAME - Gyro Orientation About X_b, gamma X_o (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

Remarks: See Remarks Word I13-10.

SUBADDRESS: 11000 WORD: I13-13

SIGNAL NAME - Accelerometer Orientation About Z_b, gamma Z_a (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

Remarks: See Remarks Word I13-10.

SUBADDRESS: 11000 WORD: I13-14

SIGNAL NAME - Accelerometer Orientation About Y_b, gamma Y_a (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

Remarks: See Remarks Word I13-10.

SUBADDRESS: 11000 WORD: I13-15

SIGNAL NAME - Accelerometer Orientation About X_b, gamma X_a (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5)
3-15	*
16	LSB (3.05176E-05)

Remarks: See Remarks Word I13-10.

SUBADDRESS: 11000 WORD: I13-16

SIGNAL NAME - Terminal Address

DATA BIT	DESCRIPTION
1	MSB
2	*
3	*
4	*
5	LSB
6-16	0

SUBADDRESS: 11000 WORD: I13-17

SIGNAL NAME - Orient Status Word

DATA BIT	VALUE	DESCRIPTION	
	00	Orient OFF/Boresight OFF	(Default)
1-2	01	Prohibited	(Note 1)
	10	Orient ON/Boresight OFF	
	11	Orient ON/Boresight ON	
	00	0 Degree Roll Orientation	(Default)
3-4	01	90 Degree Roll Orientation	
	10	180 Degree Roll Orientation	
	11	270 Degree Roll Orientation	
	00	0 Degree Pitch Orientation	(Default)
5-6	01	90 Degree Pitch Orientation	
	10	180 Degree Pitch Orientation	
	11	270 Degree Pitch Orientation	
	00	0 Degree Yaw Orientation	(Default)
7-8	01	90 Degree Yaw Orientation	
	10	180 Degree Yaw Orientation	
	11	270 Degree Yaw Orientation	
9	0	Entered Data Compare PASS	(Note 2)
	1	Entered Data Compare FAIL	
10	0	Boresight Data Store COMPLETE	
	1	Boresight Data Store INCOMPLETE	(Note 3)
11	0	Basic Orientation WITHIN RANGE	(Note 4)
	1	Basic Orientation OUT OF RANGE	
12	0	Boresight Angles WITHIN RANGE	(Note 5)
	1	Boresight Angles OUT OF RANGE	
13	0	Total Orientation WITHIN RANGE	(Note 6)
	1	Total Orientation OUT OF RANGE	
14	0	Function Reserved	
15	0	Function Reserved	
16	0	Function Reserved	

Remark: Default values represent functions or conditions which shall be assumed by the INU upon power-up unless otherwise programmed.

Note 1: This value represents a prohibited command and shall not be permitted. Attempts to enter this command shall invoke an "illegal command" error.

Note 2: This bit shall be set subsequent to any data entry command when the compare option is specified. This bit shall be set to a logic "0" if the compare was successful. A logic "1" indicates that the compare was unsuccessful.

Note 3: This bit shall be set to a logic "1" upon receipt of a command to enter boresight angles via the data bus in words D01-04, D01-05, AND D01-06. The bit shall remain set until storage of all boresight angles has been successfully completed. This bit shall be reset to a logic "0" upon the successful completion of MUX Data angle storage or upon command to clear all angles. Enable boresight functions shall not be permitted while this flag is set.

Note 4: This bit is set to 0 when commanded orientation can be accommodated by the INU without performance degradation. Bit is set to 1 if INU cannot accommodate commanded orientation without performance degradation.

Note 5: This bit is set to 0 when stored boresight angles can be accommodated by INU irrespective of orientation. Bit is set to 1 if INU cannot accommodate the commanded boresight angle(s) without performance degradation.

Note 6: This bit is set to 0 when INU can accommodate total commanded orientation (basic orientation plus boresight correction). Bit is set to 1 if INU cannot accommodate total orientation without performance degradation.

SUBADDRESS: 11000 WORD: I13-18

SIGNAL NAME - Roll Boresight Correction Angle (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.25)
3-15	*
16	LSB (.52588E-05)

Remarks: Boresighting offsets of the chassis shall be characterized as rotations of the chassis reference frame, X_r, Y_r, and Z_r to the standard orientation relative to the roll, pitch, and azimuth axes of the vehicle X_b, Y_b, Z_b. The standard orientation shall be: Roll out the nose of the aircraft, Pitch out the right wing of the aircraft, and Azimuth (Yaw) out the belly of the aircraft.

SUBADDRESS: 11000 WORD: I13-19

SIGNAL NAME - Pitch Boresight Correction Angle (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.25)
3-15	*
16	LSB (1.52588E-05)

Remarks: See Remarks Word I13-18.

SUBADDRESS: 11000 WORD: I13-20

SIGNAL NAME - Yaw Boresight Correction Angle (pi rad)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.25)
3-15	*
16	LSB (1.52588E-05)

Remarks: See Remarks Word I13-18.

SUBADDRESS: 11000 WORD: I13-21

SIGNAL NAME - Position of INU CG Along X_r (in)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (8.0)
3-15	*
16	LSB (4.88281E-04)

Remarks: The reference position of the mount diamond pin is the center of the pin as it emerges forward from the mounting surface at the rear of the rack.

SUBADDRESS: 11000 WORD: I13-22

SIGNAL NAME - Position of INU CG Along Y_r (in)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (8.0)
3-15	*
16	LSB (4.88281E-04)

Remarks: See Remarks Word I13-21.

SUBADDRESS: 11000 WORD: I13-23

SIGNAL NAME - Position of the INU CG Along Z_r (in)

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (8.0)
3-15	*
16	LSB (4.88281E-04)

Remarks: See Remarks Word I13-21.

SUBADDRESS: 11000 WORD: I13-24

SIGNAL NAME - Weight of the INU (lb)

DATA BIT	DESCRIPTION
1	MSB (30.0)
2-15	*
16	LSB (9.15527E-04)

Block ID: I14 Refresh Rate: As Required Transmission Rate: As Required

SUBADDRESS: 10100 WORD: I14-01
SIGNAL NAME - INU Status

DATA BIT	DESCRIPTION
1-16	* (All zeros for normal INU operation in accordance with paragraph 60.4.3.5)

SUBADDRESS: 10100 WORD: I14-02
SIGNAL NAME - INU Vendor

DATA BIT	DESCRIPTION
1-9	Logic "0"
10-16	* (IAW Note 1 of word I07-32)

SUBADDRESS: 10100 WORD: I14-03
SIGNAL NAME - Mode Word

DATA BIT	DESCRIPTION	
1	MSB	Function Select Code, see Note 1
2-4	*	
5	LSB	
6	MSB	Function Select Code, see Note 2
7-9	*	
10	LSB	
11	MSB	Function Operating Code,see Note 3
12-14	*	
15	LSB	
16	Logic "0"	

NOTE 1: Echo of D01-01 (Bits 2-6), Function Select Code; these bits (1-5) shall indicate the last commanded mode.

Note 2: INU acknowledge of D01-01 bit 2-6. Function Select Code is received for at least one second (See D01-01, Note 2)

NOTE 3: Present operational mode of the INU. Function Operating Codes are defined with the same five bit binary code as used for Function Select Codes (See D01-01, Note 2).

SUBADDRESS: 10100 WORD: I14-04

SIGNAL NAME - SRU Failure Indicator

DATA BIT	DESCRIPTION
1-16	* (See Notes)

Note 1: Each data bit shall represent an SRU/assembly of the INU. The description of the failed SRU shall be contained in the appropriate technical manual.

Note 2: All zeros for normal INU operation.

Note 3: Indicate all SRU's that have failed. Maintain this action until cleared via a maintenance action (same as maintenance action which clears the BITE Summary Words).

SUBADDRESS: 10100 WORD: I14-05 through I14-10

SIGNAL NAME - RESERVED

SUBADDRESS: 10100 WORD: I14-11 through I14-32

SIGNAL NAME - Contractor Unique

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APPENDIX VII

OPERATOR INITIATED BIT MODE

70. OPERATOR INITIATED BIT MODE

70.1 Introduction

Supplemental tests initiated by the operator shall be executed upon receipt of a binary Function Select Code 01001 in word 1 of the generalized CDU message D01. This mode provides the opportunity for unique contractor testing with BIT and also provides interface tests of analog outputs which will be visible on flight instruments.

70.2 Test Mode Software Functions

The system will always come up through a normal system initialization prior to entering the TEST mode unique functions. This includes Power-on, BIT, and 1553 MUX initialization. Once the TEST mode has been entered, the BIT software shall continue to receive Mode Control data for an indication of when to exit the mode. If the Gyrocompass Alignment segment has been started before another valid mode is commanded the INU shall retain alignment information already calculated to be used in the new alignment mode selected or in a selected valid navigation mode. All digital data equating to the analog functions presented in this mode shall be available on request to the INU using the normal protocol established by this specification. There may be unique contractor testing throughout the TEST mode period of 18 minutes but visual displays on flight instruments must follow a prescribed pattern. The TEST mode is broken into the following phases:

TIME	TEST MODE PHASE (Note 1)
0 - 30 seconds	System Initialization
30 seconds - 6.5 minutes	Interface Test Sequence
6.5 - 15 minutes (Note 2)	GC Alignment/NAV Ready
15 - 18 minutes	Contractor Unique Testing/TEST mode complete

Note 1: Periodic BIT tests will be run in all phases of the TEST mode.

Note 2: This phase of the TEST mode will continue until NAV READY (Full Performance Gyrocompass Align) is obtained or until a total of 15 minutes in the TEST mode, whichever occurs first.

70.3 System Initialization

This 30 second period shall be used by the contractor to perform unique initialization testing and to set up the initial conditions for the analog and digital interface testing described in the following paragraphs. The interface initialization shall be as follows:

Signal	Initialized Output
Pitch, Roll, Mag Hdg, Rel Brg	0 degrees
Attd Good, Mag Hdg Good	Not valid/off
Body Rates	0 degrees/second
Range	000 miles
Course Deviation	Null
TO/FROM	Null/off

These signals/discretes shall be initialized a minimum of 5 seconds prior to entry into the interface test phase.

70.4 Interface Test Sequence

Signals/discretes shall be output as defined below. The digital equivalent signals shall also be set such that if proper bus protocol is used they may be accessed simultaneously with the analog outputs. When a slewing type command is issued for the analog testing of pitch, roll and heading the slew rate shall be available as a body rate on the digital bus for the respective axis being tested.

SIGNAL/DISCRETE (ANALOG/DIGITAL)		TIME SEQUENCE FROM START OF SEGMENT
Attitude Good	Mag Hdg Good	
Valid	Not valid	0 - 4 seconds
Valid	Valid	4 - 8 seconds
Not valid	Valid	8 - 12 seconds
Not valid	Not valid	For rest of segment

Pitch/Pitch rate

Slew at 5 degrees/second to 90 degrees	17 - 35 seconds
Hold 5 seconds	35 - 40 seconds
Reset to 0 degrees and hold 5 seconds	40 - 45 seconds
Slew at -5 degrees/second to -90 degrees	45 - 63 seconds
Hold 5 seconds and reset to 0 degrees	63 - 68 seconds

Roll/Roll rate

Slew at 5 degrees/second to 180 degrees	68 - 104 seconds
Hold 5 seconds	104 - 109 seconds
Slew at -5 degrees/second to 0 degrees	109 - 145 seconds
Hold 5 seconds, then set pitch & roll to 0 degrees	145 - 150 seconds

Mag Hdg/YAW rate

Slew at 10 degrees/second to 180 degrees	150 - 168 seconds
Hold 5 second	168 - 173 seconds
Slew at -10 degrees/second to 0 degrees	173 - 191 seconds
Hold 5 seconds	191 - 196 seconds

Relative Bearing

Slew at 10 degrees/second to 180 degrees	196 - 214 seconds
Hold 5 second	214 - 219 seconds
Slew at -10 degrees/second to 0 degrees	219 - 237 seconds
Hold 5 second	237 - 242 seconds

Range

Step individual range digits from 000 through 009 to 010 through 090 to 100 through 900 to 000 at a 2 second/step rate	242 - 296 seconds
Hold 5 seconds	296 - 301 seconds
Step range digits collectively from 000 to 111 through 999 to 000 at a 2 second/step rate	301 - 321 seconds
Hold 5 seconds	321 - 326 seconds

Course Deviation

Step course deviation bar from null to +FS to +1/2FS to null to -1/2FS to -FS to null at a 3 second/step rate	326 - 344 seconds
Hold 5 seconds	344 - 349 seconds

TO/FROM

Step TO/FROM flag from null to TO to FROM to null at a 2 sec/step rate	349 - 355 seconds
Hold 5 second	355 - 360 seconds

END of Interface test mode

Time in Test is 6.5 minutes

70.5 Gyrocompass Alignment in Test Mode

A normal Gyrocompass alignment shall be performed at the completion of the Interface Test Sequence (6.5 minutes after entry into the TEST mode). At this time, the TIME IN ALIGN clock shall be started. Allowance shall be made for present position to be entered anytime in the first 8.5 minutes of the TEST mode. If Present Position is entered after 8.5 minutes in Test Mode (2 minutes into GC Alignment) the TIME IN ALIGN counter shall be reset and the Time in TEST Mode counter shall be reset to 6.5 minutes. All flags, discretes, 1553 MUX operation, etc, shall be driven as though the INU was performing a normal gyrocompass alignment. If the alignment is successful within 8.5 minutes of entry into Align, I06/I08 word 01 bit 10 shall be set to zero (indicating that the TEST MODE has completed) and I06/I08 word 01 bit 16 (NAV ready) shall be set. If the GC Alignment is unsuccessful I06/I08 word 1 bit 10 shall be reset to 0 after a total of 18 minutes have elapsed since entry into the test mode. The INU status relating to failures shall be reported in I06/I08 word 01 (NAV ready, bit 16 shall not be set). Also, INU failures shall be reported in BIT records stored in miscellaneous word 2 (for depot use) and miscellaneous word 1 (for BIT history).

70.6 Contractor Unique Testing in Test Mode

The last three minutes of the Test Mode (15 to 18 minutes) is reserved for contractor unique testing of the INU in order to meet the fault detection requirements of paragraph 3.2.1.10j. The INU shall not degrade a successful GC alignment (accomplished via paragraph 70.5) by any unique testing done in the last three minutes of tests mode. All status and validity flags shall be set or reset, as appropriate, during the final three minutes of the Test Mode to be consistent with the digital and analog output data. The I06/I08 Word 1 Bit 10 shall be set or reset after a total of 18 minutes have elapsed since entry into the test mode, provided present position was not entered after 8.5 minutes in test mode. The INU BIT status shall be updated relating to miscellaneous word 2 (for depot use) and miscellaneous word 1 (for BIT history).

Table VII - "S"-Turn Flight Profile

1. Align the INU at 0 degree heading.

2. Select navigation pitch = 0 degree.

3. Roll in a positive direction to 80 degree right wing down and change heading at a +3 degree/sec rate to -45 degree heading (30 sec).

4. Repeat the following cycle 15 times:

(a) Roll in a negative direction to 80 degree left wing down and change heading at a -3 degree/sec rate to -45 degree heading (30 sec).

(b) Roll in a positive direction to 80 degree right wing down and change heading at a +3 degree/sec rate to +45 degree heading (30 sec).

5. Roll in a negative direction to level and change heading at a -3 degree/sec rate to 0 degree heading (15 sec).